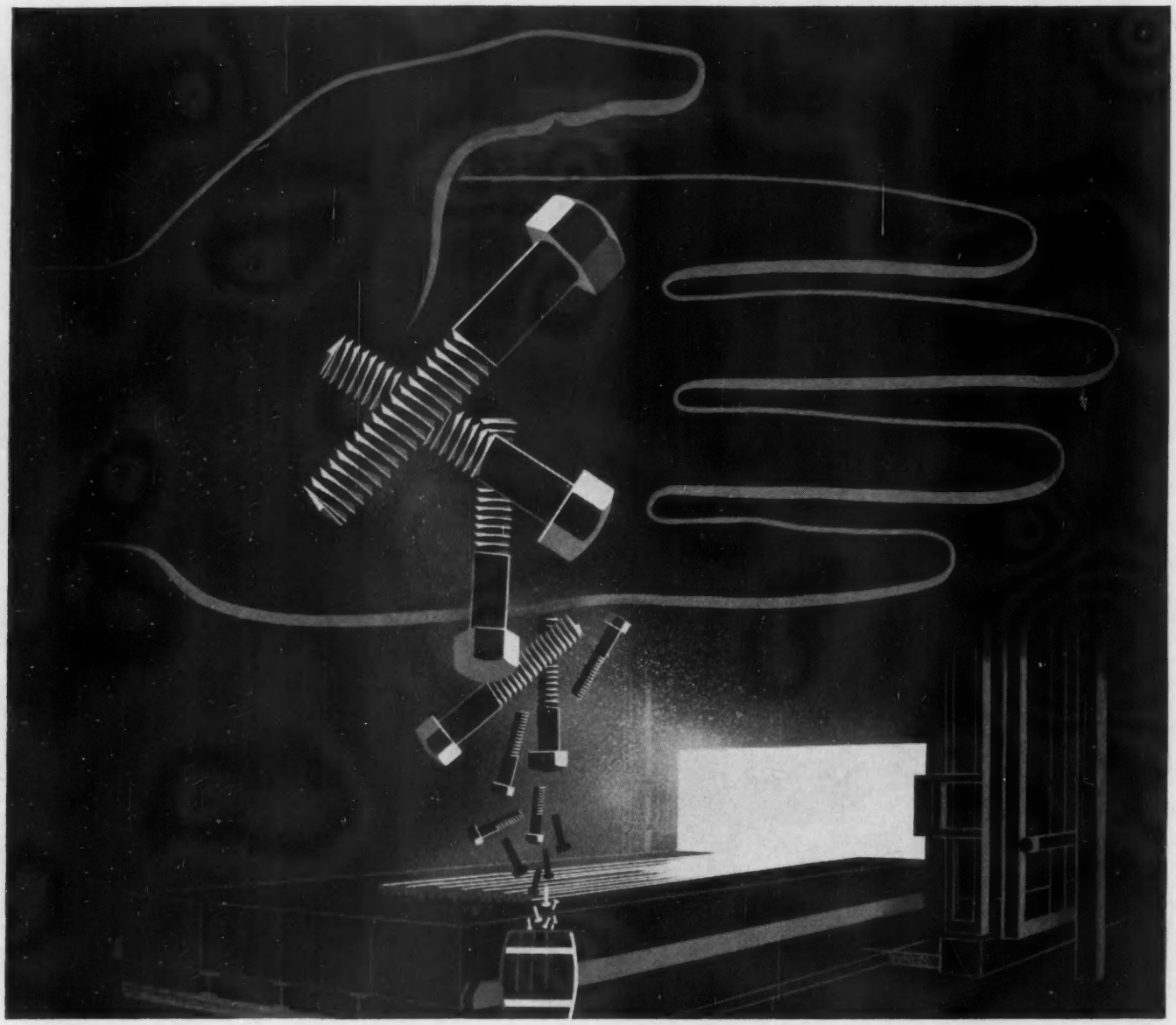
THE TECH ENGINEERING NEWS

Massachusetts Institute of Technology • 1938 • *March*



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AUTHORS

DR. MATTHEW LUCKIESH received a thorough training in electrical engineering before starting his research work with the General Electric Co. He attended Purdue University, the State University of Iowa and finally Iowa State College, where he served two years as an instructor. From there, in 1910, he went to General Electric in the capacity of research engineer. He was made Director of the Lighting Research Laboratory in 1926. Dr. Luckiesh is the author of several books dealing with his researches in the field of light. His article, *This Half-Seeing World* is a survey of some of his latest work.

CHARLES MILTON ATLAND STINE, director of the chemical department of E. I. duPont de Nemours Co. since 1924, and now Vice President, received his education at the Gettysburg Pennsylvania College and at Johns Hopkins University, obtaining his Ph.D. degree in 1907 from the latter institution. He has developed several processes and patents in both the inorganic and organic chemical fields.

PETER GRIMM was graduated from Columbia University in 1911 with the degree of Bachelor of Science and immediately entered the real estate business. In 1929, he became president of the Wm. A. White and Sons, the company that assembled Rockefeller Center. Other civil and commercial positions that he has held are: President of Building Managers and Owners Association, President of Real Estate Board of New York, Inc., Chairman and Trustee of Citizens Budget Commission, Real Estate Advisor to Municipal Housing Authority. He was also Assistant to the Secretary of the Treasury and Assistant Director of the National Emergency Council in 1935.

MONARCH L. CUTLER, '39, author of the article on *Polaroid*, is a former Associate Editor of the TECH ENGINEERING NEWS, and is the author of a previously published article on *Bakelite*. He is now studying in Option 2 of Course VIII with his major professional interest centered around optics. As a member of the M. I. T. Physical Society, he holds the position of Secretary-Treasurer.

PREVIEWS

All important at this time is the subject of Germany's resources, especially the latest developments in synthetic fuels and other vital products, such as rubber. Dr. Bertsch, German-American chemist, who is particularly well qualified to write on this subject, presents his views on the "German Four Year Plan" in the coming issue.

Weather forecasting seems necessary to most of us but few realize the part it plays in modern industry. Well suited to speak on this subject is Mr. E. B. Rideout, pioneer meteorologist of thirty years experience, now on the staff of station WEEI, Boston. Mr. Rideout writes in April's TECH ENGINEERING NEWS.

H. C. Lawrence, M. I. T. class of '38, shows readers of April's TECH ENGINEERING NEWS the present condition of television, both as to its possible practical applications and laboratory developments. Although now a curiosity in this country, tomorrow's television may be as common as today's radio.

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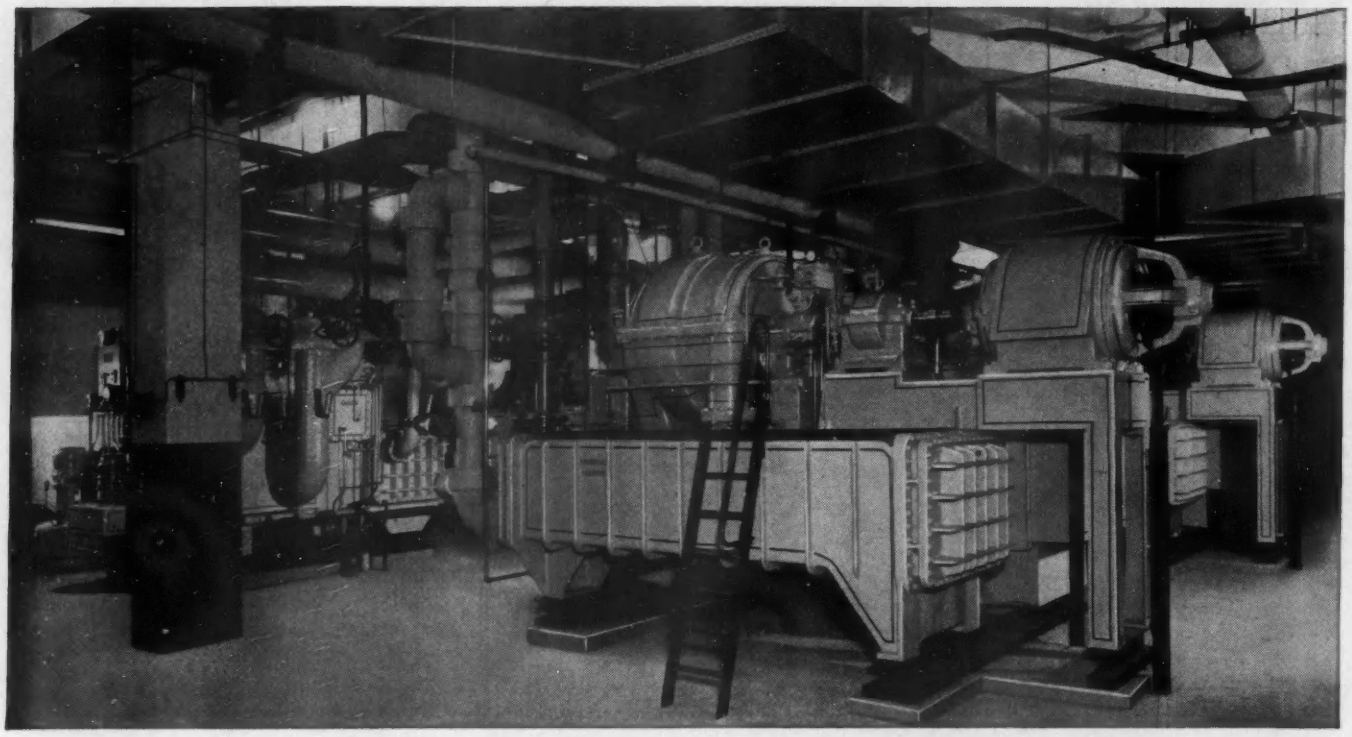

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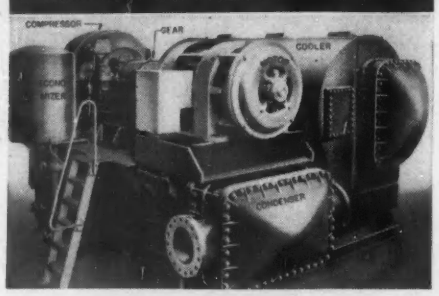
Above: Carrier Centrifugal Refrigeration machine providing refrigeration for air conditioning of skyscraper. *Below:* Diagram of construction.



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Volume XIX Number 2

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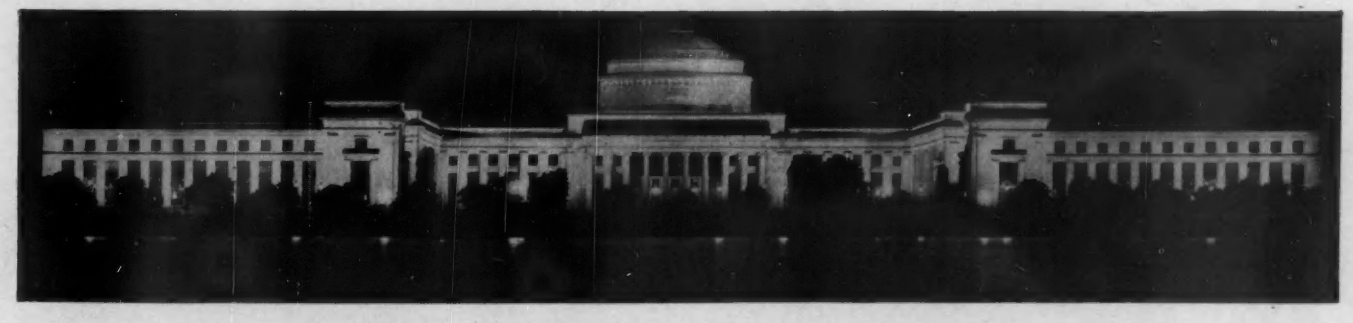
Our Cover This Month

The lines and shadows in the "U" show the location of strains in the object, and points of failure. It was only after Polaroid was developed, that such large "strain maps" could be produced.

—Courtesy The Polaroid Co.



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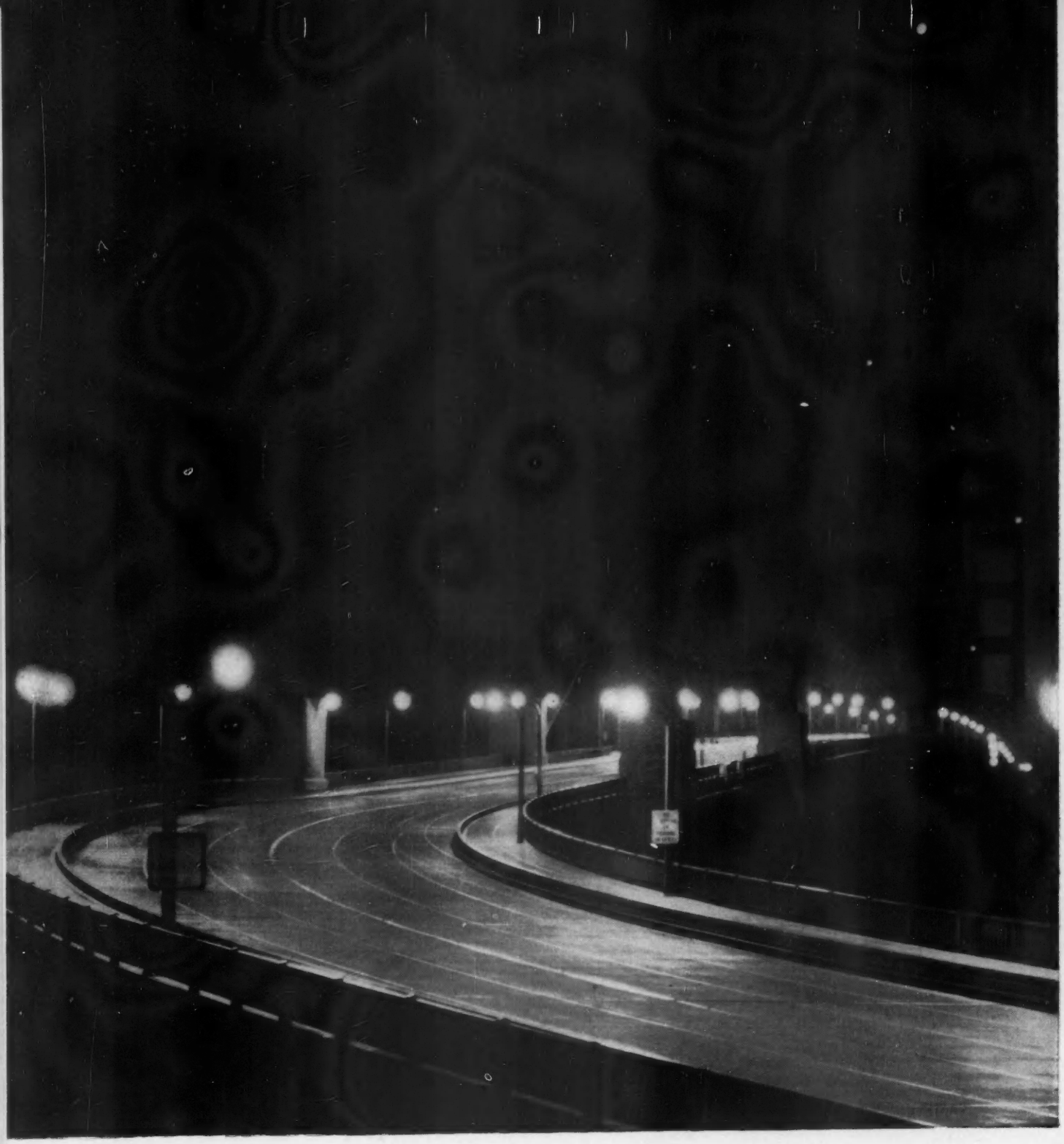


PATH OF GOLD

This Half-Seeing World

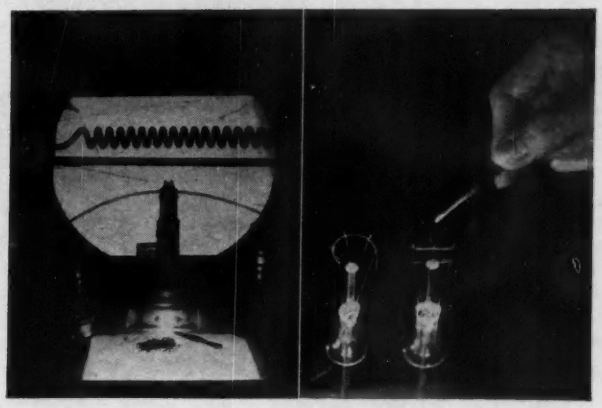
Efficiency, Eye Fatigue, and Artificial Lighting

MATTHEW LUCKIESH

THIS is a half-seeing world in two senses. It is half-seeing because of inadequate light in a world which has been satisfied to barely see instead of to see easily. This is also a half-seeing world because of our great lack of knowledge. Knowledge makes our minds see—makes us understand. These two kinds of seeing are the most important functions of human beings. They are intimately bound together. The development of a science of seeing is revolutionizing the old viewpoints of lighting and of vision. It touches every civilized human being. Of such magnitude, it has a right to be classed as a revolution and to be discussed in connection with other great revolutions. Civilized progress is achieved mainly by revolutions superposed upon a slow but orderly current of steady evolution. Revolutions are merely periods of increased tempo. They are the occasional rapids between stretches of slow-moving current. In the hurry and confusion of the rapids there is more or less froth and foam, but there is definiteness to the direction and power of progress.

These revolutions are declarations of independence from the old order. The first beings who entered caves thereby issued the first declaration of independence from Nature. They sheltered themselves from the elements. They built fires in those caves and thereby issued a declaration of independence from darkness. It seems to me that civilized progress has always been a struggle against darkness, a struggle that civilized human beings might see with their eyes—and with their minds.

Artificial light has always been the torch of material civilization. It penetrates the darkness of night and of the artificial world which man has built. It is a proper symbol for knowledge, which likewise penetrates the darkness of the unknown surrounding us. With knowledge our mind sees—that is, we understand. We illuminate physical things if we are to see them. We illuminate them with knowledge if we are to understand them. From the very beginning, and even now, the artificial world of civilization has been built with knowledge—but also in ignorance. What we know is always such a small percentage of what we should know, but that percentage is rapidly increasing, thanks to a great invention perfected about three centuries ago.



— *Courtesy General Electric Review.*

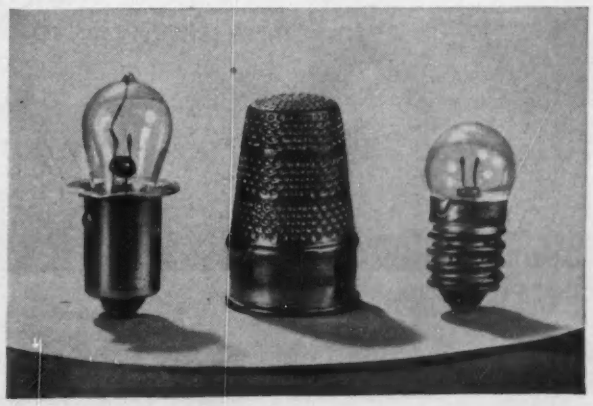
At left, enlarged silhouettes of new high-efficiency tungsten lamp filament with section of older type coiled filament and strand of human hair; at right, comparison of old and new filament mountings.

For uncounted thousands of years, since the first feeble steps were made by primitive men along the pathway of civilization, the growth of knowledge was solely by the slow and painful method of everyday experience. Throughout those ages of unwritten history no systematic attack against the unknown was made. Greece and even Rome rose to great heights along some of the highways of civilization without developing a suitable method for acquiring knowledge. The dark Middle Ages expended energy and men in two occupations—war and religion—without finding the key which unlocks the door to incontestable knowledge.

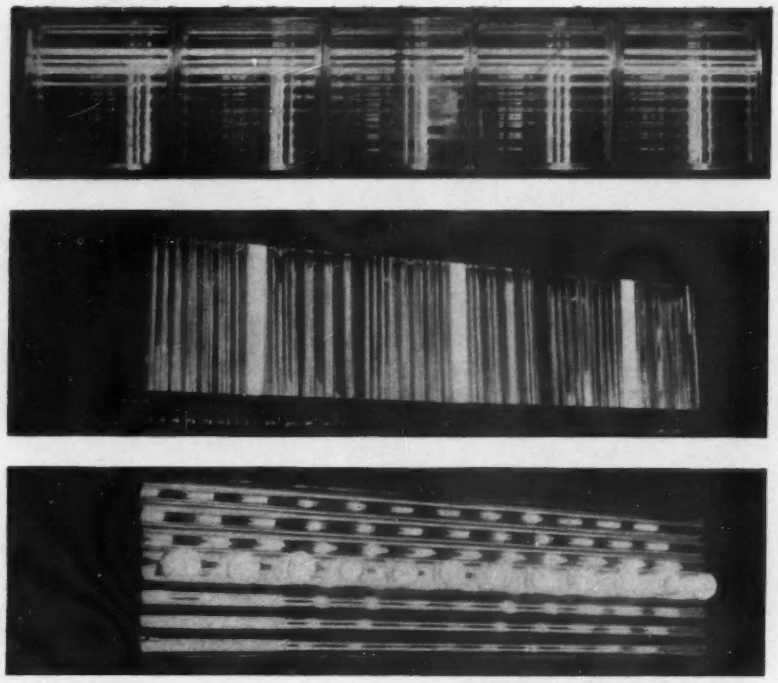
Then there came another of those periodic revolutions—the Renaissance—which left posterity the greatest heritage of all time. As we study the revolutions of the past, and particularly that last great one, we find much hope in the present one which has been brewing since the beginning of this century. The Renaissance of a few centuries ago was also a declaration of independence. It was a demand for independence in thought and action in art, science, religion, economics, and government. It was a rebellion against the shackles of traditions, against the old order, against the tyranny of ignorance and prejudice. It was a maelstrom of conflict of classes, of ideas, of kings, philosophers, artists, priests, and popes. Doubtless everyone had his worries and doubts three hundred years ago. But now, as we view the Renaissance in the light of progress which followed, we find that its contributions were enormous.

A new prefocused flashlight lamp (left) designed to prevent distorted beams, provide brighter spots of light, and increase seeing range.

— *Courtesy General Electric Review.*



The Renaissance gave birth to the greatest idea and invention of all time. For the first time in all the centuries of recorded history and in the uncounted thousands of years since the beginnings of civilization, mankind clearly accepted the idea that Nature could be understood and was worth understanding. For the first time man perfected the only dependable truth-getting device that ever was invented. This device is the modern



Glass bricks lighted from behind to study effective reflectivity of metal surfaces.

— *Courtesy General Electric Review.*

scientific method—the systematic attack against the unknown by systematic experiment. This yields tested and testable knowledge—and therefore incontestable knowledge. And modern science in general, or any science in particular, consists of such incontestable facts and their correlations. Modern scientific method substituted experimentation for philosophizing. At least scientists safely philosophize *after* the facts instead of *before* them. Systematic testing by experiment has taken the place of preconceived ideas. No longer do we believe to be true that which seems likely to be true. Tested and testable knowledge are the only materials in modern scientific structures.

Thus the great heritages, bequeathed to posterity by that revolution which we have named the Renaissance, went to work for civilization. *We shall understand!* became the theme of the truth-getters and *Systematic experimental method!* became the mode of attack. Modern scientific method is the only device which reveals the "*unobvious*." For example, electricity is "unobvious." Although only a century ago Faraday was performing the first fundamental experiments in electromagnetism, the applications of electricity had already greatly altered civilization. In a century modern scientific method has made this an electrical world. During the past century we have learned nearly all we know for sure about anything and everything. Truly modern science is a great heritage and we owe it to the last great Revolution.

Let us now return to our artificial world which has been built of knowledge and also in ignorance. Modern science performs simultaneously the office of vanguard and rearguard, providing new knowledge for new progress. It also examines our ways of living and reveals the penalties of ignorance. I am going to describe briefly a recent and important rearguard service which modern science has rendered. By no means is it completed, but a quarter of a century of research has developed the new science of seeing which civilization has sorely needed for centuries and which is of vital importance to everyone.

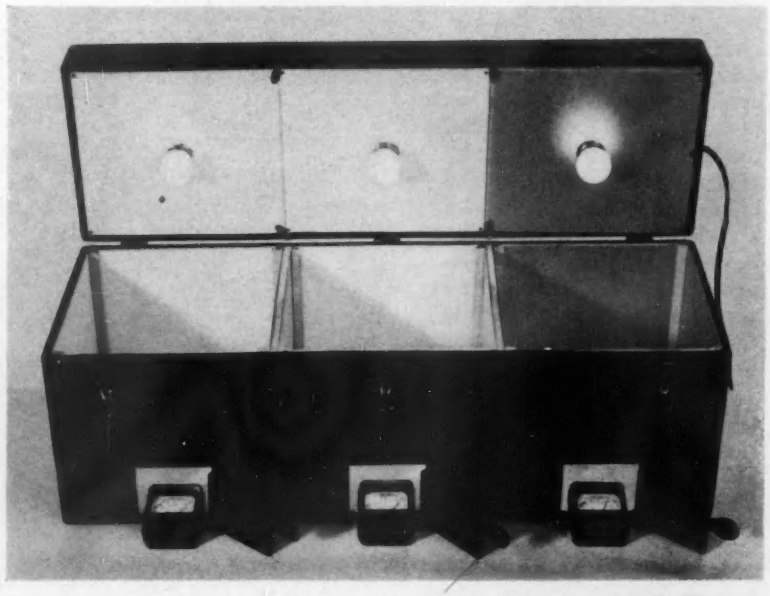
Eyesight is one of the most important possessions of a human being. At least it has few rivals for that position. Pursuing the same logic, *seeing* is our most important controllable activity. At least it has few rivals in that respect. Pursuing the same line of logic further, *light* is just as important to human beings as eyesight because the latter is worthless without it. Therefore, lighting is not only essential to seeing, but it becomes very important in this complex artificial world with its unnatural tasks and conditions.

When three centuries ago the desire for incontestable knowledge became deeply rooted and that truth-getting method was perfected, it was natural that the physical sciences developed first. Without a foundation of physics and chemistry, such sciences as physiology and psychology could not develop. As a consequence, the physical aspects of light, lighting, and vision became well developed. The production and control of light are physical sciences. Likewise the correction of eye-defects with glasses is a physical science. These sciences have been developing for a long time, but they do not deal with *seeing*. They deal merely with tools essential to seeing. For more than a quarter of a century I have been associated with a continuous line of researches pertaining to lighting and vision, but it required much research and thought to awaken to the fact that science had been studying *tools* for seeing instead of *seeing* itself.

Then came a great awakening, which has resulted in the development of the new science of seeing. It seems simple now, but it was not simple then. We conceived the idea that we are *human seeing-machines*—that seeing is an activity of human beings operating as seeing-machines—that this activity involved more than light and eyes—that it consumed human energy and wasted other human resources. Thus, for the first time we began to study seeing as *work* which human beings do. Already we know that seeing tires *us*, not merely our eyes, and that it results in many deep-seated psychophysiological effects that are not obvious. Many other new concepts, facts, and correlations have been revealed, and new ones are continually on the way.

As human seeing-machines, we have a right to know what

— *Courtesy Magazine of Light.*



Apparatus used for demonstrating reflection factor of various colors and types of paint.

— *Courtesy Magazine of Light.*

A classroom with unimproved lighting installation.

seeing costs us in the waste of human resources. Our efficiency as seeing-machines is not truly measured by the amount of useful work we do per dollar or per hour. Our true efficiency is measured as in the case of any machine. It is the ratio of the useful work we do to the total (useful plus useless) work we do. We have a right to know something of the internal losses corresponding to friction and other useless work of real machines. We are finding out such things.

As human seeing-machines we are interested in three things: (1) the visual task; (2) the eyes or visual sense; and (3) light and lighting. The science of seeing provides new information pertaining to each of these factors, and reveals what can be done to improve seeing conditions. This resolves itself into a question of controllability of any factors involved. Generally we must accept visual tasks as we meet them. After sharpening our eyes with glasses, if they need them, we can do nothing more about them. However, most of us everywhere can increase the amount of light available, and often can improve the lighting. It is generally somewhat under our control. We can move closer to a window or move a lamp closer to us. Light and lighting are usually controllable by us or by someone else. Thus, lighting practice is promoted from its present insignificance to a major role.

Now let us examine lighting. It is a chain of three links; (1) production of light; (2) control of light; and (3) specification of light and lighting. Production and control of light are physical sciences. These links are well forged, but the third link—specification of light and lighting—has been a weak makeshift. Certainly, it is not a science or even an empirical art. It has been a crude art at best. Thus, the lighting specialist has had available excellent light-sources and the knowledge necessary to control light. He could bring it to the user and then his knowledge gave out, for he had no scientific basis for specifications. Production and control of light are physical sciences, and in applying them he got the idea that lighting was engineering in its common sense. But specification of light and lighting for human seeing-machines is necessarily a psychophysiological science. It deals with light for seeing, and seeing involves deeply hidden physiological and psychological effects. The development of a science of specifications naturally had to await its turn in the development of the sciences in the order of physical, physiological, and psychological.

The new science of seeing is providing a science of specifications of light and lighting. To do this it had to begin at the beginning. It had to consider the natural conditions under which human beings and their eyes evolved outdoors. It had to compare those conditions with the present ones in our artificial world, and it found an enormous difference. Biologically speaking, we were primitive beings living under natural conditions yesterday. Today we have greatly altered them. As primitive beings we had evolved through eons under Nature's peculiar and bountiful light and Nature's own lighting. The visual tasks were easy ones. Close work was casual. Now, as human seeing-machines in a complex artificial world, we are engaged in close work for many hours daily under greatly restricted light and altered lighting. Seeing became commonplace to us before we were old enough to think and analyze. Therefore, the penalties are deeply hidden. In the commonplaceness we have no consciousness of lighting and seeing. Our consciousness is aroused only under extreme conditions of obvious effects such as strain, headaches, and other disorders. But the waste is going on all the time.

The science of seeing has already explored many highways and byways, but we shall touch upon only a few points. In the first place, let us measure light. At a distance of one foot from an ordinary lighted candle we have one footcandle. Throughout this artificial world of ours we find the quantity of light on our visual tasks the same as it was in the age of candles. It is generally only one, two, or three footcandles. Now let us go to the window in the daytime. Our footcandle meter will commonly indicate 50 to 300 footcandles. Outdoors in the shade of the porch or a tree on a sunny day we may find 300 to 1000 footcandles. At noon on a clear day in summer we measure from 7000 to 10,000 footcandles. Thus, in building our artificial world in ignorance we have supplied only a footcandle or two upon unnaturally severe tasks which are products of our civilization. Outdoors, when we were primitive beings yesterday, we engaged in casual easy visual tasks and we had hundreds and even thousands of footcandles.

Studies of vision merely reveal threshold or minimum conditions. The science of seeing, which takes into account the effects of seeing upon tenseness, heart-rate, blinking, and eye fatigue, aims to reveal conditions for easy and easiest seeing.

(*Continued on page 48*)

— *Courtesy Magazine of Light.*

The same classroom with a new lighting installation.

Polaroid

MONARCH L. CUTLER

MARK TWAIN asserted that everyone talks about the weather, but nobody does anything about it. A similar situation has, until recently, existed in the field of polarization of light.

For over two centuries the polarizing of light has been discussed in laboratories and at scientific gatherings; much has been written concerning this characteristic of light. Polarization has been discussed and demonstrated on the small scale in many high schools and colleges, but until the last few years little commercial success has occurred in attempting to bring polarizing materials to the public's use. Many patents have been granted for instruments that would be of great service to the public, but the joker in each case has been that no polarizing medium existed that could make the use of these instruments practical.

For the past fifteen years, Edwin H. Land, a young Harvard graduate, whose home is at Wellesley, Massachusetts, has been studying polarizing mediums. He continued the work of an English physician, Dr. William B. Herapath, who in 1852 discovered a series of organic crystals that had the property of polarizing light. A few years ago, Land finally produced a material that can be manufactured inexpensively and on a large scale.

Polarization, often called the third property of light (color and intensity may be considered the first two), was first witnessed when Erasmus Bartholinus placed a calcite rhomb on some writing and saw the image doubled. Twenty-eight years later, in 1698, Huygens placed a second rhomb on the first; he saw four images and promptly called the phenomenon "the strange refraction" of calcite. He was able to devise constructions that indicated the paths of the rays in the crystals, but he was nevertheless unable to explain "this strange refraction." His difficulty, we now know, centered around the supposition that radiations vibrated longitudinally, as do sound waves.

When Young, a century later, hypothesized that light waves vibrate transversely, the mysterious phenomenon that Bartholinus and Huygens had witnessed was readily explainable. If natural light radiates transverse waves in all directions, these waves may be regarded as vectors. As vectors they may be divided into two components, one horizontal and one vertical. If one of these components can be removed, the radiation will vibrate in only one direction, or one plane. Light treated thus is said to be plane polarized and the plane of polarization may be considered normal to the plane of vibration after polarization.

To crudely illustrate this effect, let us attach a rope to a wall and shake one end of the rope in a random manner. Waves, analogous to light waves, are thus propagated along the rope. If the rope passes through a gap in a picket fence, all of the vibrations will not get through, but the ones that do will all be parallel to the gap between the palings. It is this arrangement of the vibrations in one plane that makes the light controllable, for when a second "fence" is placed with its "pickets" at right angles to those of the first, the vibrations cannot pass, and no light is transmitted. When the polarizing "slots" are parallel they are said to be *optically coincident*, but when they are at right angles, they are *optically crossed* and the second "fence" rejects the polarized light passing through the first medium. In working with light, there is one polarizer to produce the polarized light and a second one, called the analyzer, to select or reject it.

Polarized light may be produced in a number of ways. The most common, perhaps, are scattering and reflection; an example of the former is skylight, which, because of scattering caused by particles in the atmosphere, is partially polarized in a band perpendicular to the direction of the sun; the latter is produced by reflection at certain angles from mediums such as water and glossy surfaces. Another method of polarizing light is by refraction, which is the principle of the previously mentioned calcite rhomb.

The manner of polarizing light that is of present interest to us is that utilized in Polaroid—absorption. In absorption, either the horizontal or vertical component is absorbed by the polarizing medium, and the other is allowed to pass through to the analyzer, if one is used. Probably the earliest known example of this method is the use of the natural crystal, tourmaline.

Other and more powerful substances are some of the periodides of quinine and the sulphates of cinchonidine. Their

Figure 1. At left, an ordinary photograph showing strong glare on road surface, and, at right, a photograph with the glare eliminated by a Polaroid lens.

— Illustrations Courtesy Polaroid Company.

Figure 2. These photographs illustrate the advantage of a new Polaroid lamp, which eliminates glare from magazine pages. No glasses are required.

polarizing properties were discovered in 1852 by Dr. Herapath and were extensively worked on for several years afterward; one has become known as *herapathite*. Herapath attempted to convert his minute microscopic crystals into areas large enough to cover the objective of a microscope. He devised numerous methods of obtaining sizable areas, but in all cases the crystals were either too small or extremely fragile. Where Herapath failed to produce large and stable areas of polarizing medium, Edwin H. Land succeeded. Rather than attempting to produce a single, large crystal, he grew extremely small ones and used many of them in a single sheet.

The crystals, iodo sulphate of quinine (herapathite), are dichroic, a red-green when comparatively large, and olive-green when a powder or of the order of magnitude of those used in Polaroid. They are needle-like and must all be oriented in the same direction in order to act as a polarizer. After they have been oriented, a binder of cellulose acetate holds them in their new positions.

There are a number of possible ways in which the long, narrow, dichroic crystals may be aligned in their matrix of cellulose. Mr. Land has said that the process of orienting these crystals may be likened to the orientation of a pencil placed on a sheet of rubber. If the rubber is stretched, it will be noticed that the pencil tends to align itself in the direction of the stretch. Mr. Land has cited in his patents that this stretching process may be applied to the cellulose suspension of herapathite crystals by electrical, magnetic, gravitational, or mechanical forces. One of the mechanical methods mentioned is to place the colloidal suspension in a chamber and extrude it through a small slit and consequently orienting the particles in the direction of this stretch.

The Land patents mention that the regular distribution of the particles in the outer layer of the suspension may be disturbed by the retardation of these layers as they are extruded through the slit. To overcome this danger, a thicker layer of the viscous cellulose acetate, containing none of the polarizing herapathite, may be placed above and below the central layer which is impregnated with the dichroic crystal. The three layers may then be extruded from the chamber through the slit, and thus the central layer is subjected to pure stretch, which is desired. The same result could be obtained by rolling the three layers of the jelly-like material.

The resulting film, which resembles cellophane, and is as flexible, appears to be unaffected by age, vibration, ultra-violet light, or temperatures to 250 degrees Fahrenheit; it must, however, be protected from moisture, and for this reason it is always laminated between glass or plastic sheets. The crystals are so small—of the order of magnitude of the wave length of light—that they cannot be seen under a high powered microscope and are distributed throughout their matrix in the neighborhood of one thousand billion to the square inch.

The polarization is accomplished by simple transmission with very little scattering. It is substantially complete except at the extreme end of the visible spectrum, where visibility is low. At one end of the visible region, the violet end, the absorption is so strong that the films appear practically opaque. At the red end of the spectrum the polarization also decreases very rapidly, but since the medium is very transparent to infra-red rays, two crossed films prove to be a good infra-red filter. Figure 3 illustrates the general polarization and transmission characteristics within the visible region. The graph applies to standard Polaroid in which the film is mounted between thin plates of glass. No corrections are made for reflection or collateral absorption losses. The values of transmission greater than 0.50 are possible by virtue of the imperfect polarization at the red threshhold of the spectrum; it is realized, of course, that for perfect polarization, the maximum transmission is 0.50. The effective average transmission of Polaroid is 0.37 and may be compared to that of the Nicol or Glan-Thompson prisms which has been stated in the sales literature of Zeiss to be 0.40. By using thinner Polaroid films at a slight sacrifice of polarization, transmissions greater than 0.40 are easily attainable. The degree of polarization is expressed as

$$V = (1—R)/(1+R),$$

where R is the ratio of the intensities of the undesired and desired components of the transmitted light.

For certain phases of scientific work the olive-green color and the high absorption characteristics of the polarizing medium may be found a disadvantage. At a meeting of a section of the Society of Chemical Industry, held last May at South Kensington, England, Dr. F. D. Miles stated that he found these restrictions a hindrance, particularly for photomicrography. Professor Freudlich, who presented a paper at this Symposium, said that there is no need to exclude the possibility of finding other materials more suitable than herapathite in the matter of color. Of course, this does not mean that a colorless polarizer will necessarily have less absorption.

It has been said that another substance, chloropurpureocobalt sulphate periodide, is superior to herapathite with reference to the degree of polarization and to the amount of polarized light passed through. As was mentioned earlier, there are a very great number of salts that show polarization capabilities, and no doubt others are yet to be found.

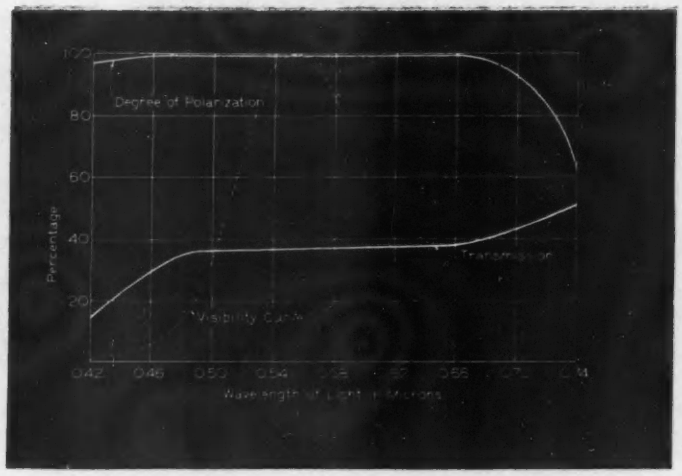


Figure 3.

For utilization, the Polaroid film is always mounted between glass or plastic sheets to protect it from moisture and has the appearance of modern safety glass. The characteristics of this plate are such that Polaroid may be put to numerous commercial as well as scientific uses.

At the present time one of the greatest interests in commercial applications of Polaroid is its use in the elimination of glare from automobile headlights (*Tech Engineering News*, 18:87, May 1937).

In one of the proposed systems, light emitted from the headlights is polarized at an angle of 45 degrees, and the road is viewed through a Polaroid screen set in the windshield at a 45-degree angle, so that one has a clear view of the road ahead. Headlights coming from the opposite direction show only a faint reddish glow (figures 2), since the Polaroid on these headlights is optically crossed with the polarizing screen on the first automobile windshield. Of course legislation must be adopted to standardize the use of these screens. If such legislation were adopted, it would permit more powerful headlights to be used and adjusted at a higher angle; also, dimming of lights would be unnecessary when cars pass on the open road. An adjustable polarizing windshield set at the correct angle would serve to remove glare caused by light reflected from the road surface when it is wet, as well as when it is dry with a strong sun beating down upon it (figure 2).

The use of Polaroid glasses is rather versatile. A ship's pilot can study conditions of the bottom, as indicated by the color of the water, with much greater ease when reflected glare is absent. An airplane pilot flying over water finds visibility much improved when reflected glare is reduced. In the peacetime practice of the Coast Artillery, the sea must be carefully scanned for ships during target practice, lest they be in the field of fire. The use of Polaroid glasses would eliminate glare and thus greatly reduce the tremendous eye strain that is found to occur in this task. Polaroid discs can be used in various telescopic and observing instruments that are employed in artillery. Many personnal errors caused by observers would probably be eliminated from the firing data, since the strain upon the observers' eyes would be less.

Polaroid glasses should appeal to beach-goers, skiers, and mountain climbers, who, at present, use ordinary sun glasses. The Polaroid lenses reduce glare by eliminating the polarized light from specular reflections, from snow fields, and from the blue sky; they also prevent dilution of colors and thus add new beauty to the natural scenery.

A new beauty may be easily added to pictures of those scenes by the use of a Polaroid screen that is attached to the camera in the same manner as is an ordinary filter. It is placed in front of the lens and serves to cut off undesired reflections from glass, water, or polished surfaces, so that detail beyond or beneath the reflecting surface is clearly visible (figure 4). By rotation of the polarizing disc, the polarized section of the sky can be made to appear any shade of darkness that is desired while the foreground remains as before. This supplementary screen will facilitate reproduction and copying. With a polarizer over both the source and the camera lens, pictures need not be removed from their frames, since reflection from the glass is easily eliminated by polarization. Oil paintings can be photographed without fear of undesired glare from the paint pigments or shiny surfaces. For advertising purposes, any polished or shiny surface, such as silverware or glassware, may be reproduced with excellent results.

Polaroid reaches also into the field of advertising display. When a thin film of mica or cellophane is placed between pieces of Polaroid, brilliant colors appear in the film. Different thicknesses of film produce different colors, while the rotation of one of the Polaroid discs through 90 degrees produces mathematically precise complementary colors, a change that can be

(*Continued on page 49*)

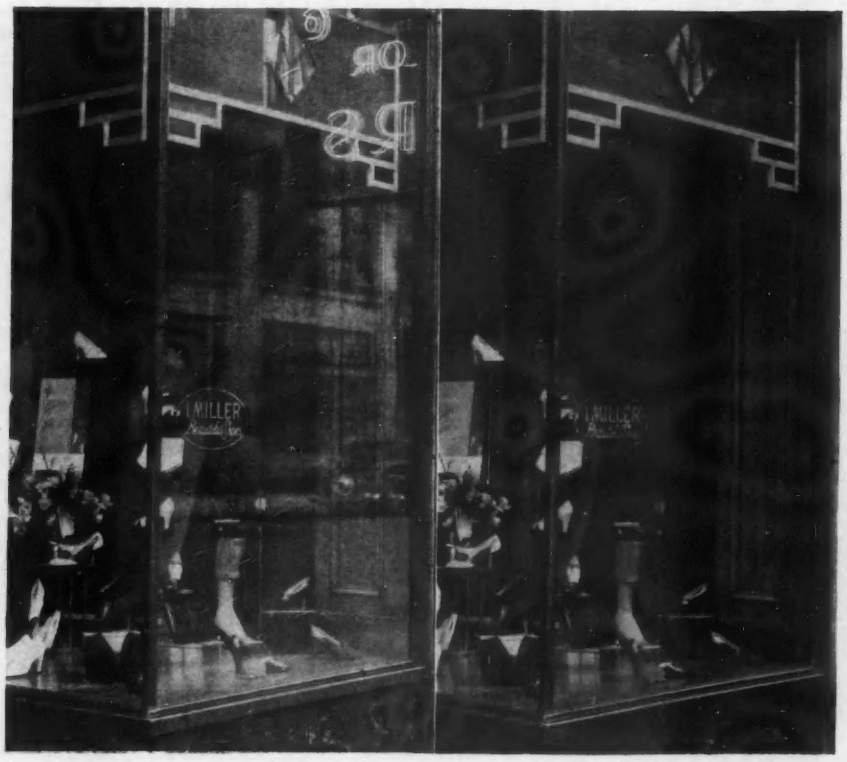


Figure 4 Another illustration of glare-elimination by Polaroid.

Industrial Progress in Organic Chemistry

C. M. A. Stine

THE readers of this magazine are familiar with the work of the German chemist, Wöhler, in 1828 on the synthesis of urea, and with that of the English chemist, Perkin, in 1856 which resulted in the synthesis of a dye from a coal tar derivative. Probably the readers are also familiar with the work of the German chemist, Sapper, in 1896, which is often cited as an illustration of the effect of the use of catalysts upon chemical reactions. I merely mention the foregoing examples in order to point out the truth that a long period of discovery and exploration preceded the intensive activity of recent years, especially of the past twenty years. The task of the early investigators was to establish a broad and firm foundation for the complex superstructure of today's organic chemistry. Nearly all of the organic research was done in the universities, so that the objectives were primarily non-commercial. Many of the discoveries, such as Perkin's discovery of mauve, though accidental, served to open up tremendously important commercial fields.

Today the situation is different in that thousands of chemists, comprising a majority of those engaged in organic research, are employed by industry and are working toward definite commercial objectives. Progress in the fundamental science, however, is not being retarded by this commercial emphasis. On the contrary, an inescapable by-product of industrial research is discovery of a kind that contributes to the basic knowledge.

Many examples might be cited to indicate how the organic chemist is producing new things in response to specific needs. Thus, a compound has been synthesized which renders textile fabrics permanently water repellent. Although waxy water-repellent substances have been used many years, they are not particularly resistant to dry cleaning or repeated laundering. The new compound becomes integral with the fiber and is therefore permanently effective.

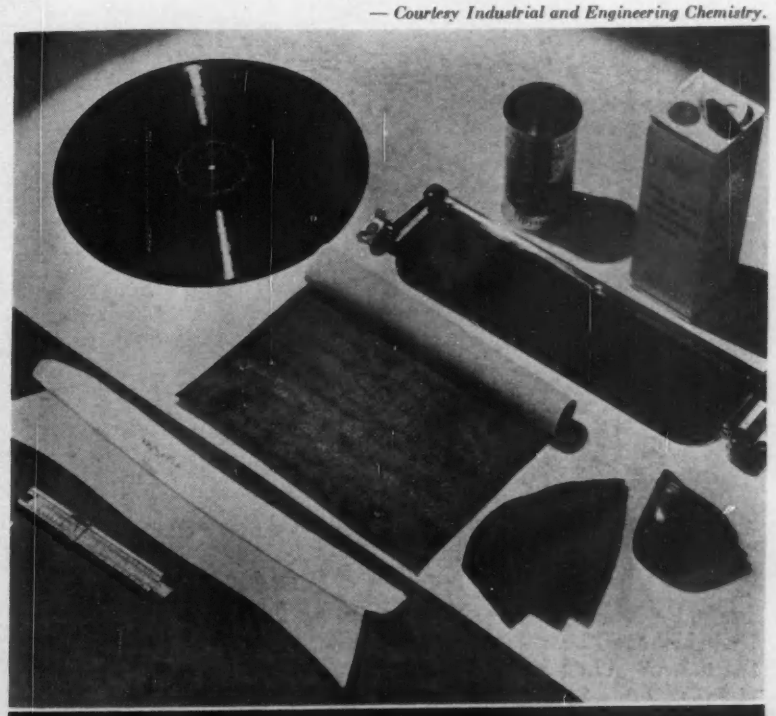
Blue stain in freshly-sawn lumber formerly cost the industry about ten million dollars a year. Badly stained lumber was difficult to sell at any price. Treatments to prevent the stain were costly, required temperatures so high that a yellowish color was imparted to the wood, and were not wholly effective. Synthetic organic mercurials, as for example, ethyl mercury chloride, were found to be effective in protecting all varieties of woods against the stain, which is caused by fungi. Moreover, the fungicide is applied in solution at ordinary air temperatures. Several billion board feet of lumber a year are now treated in this way.

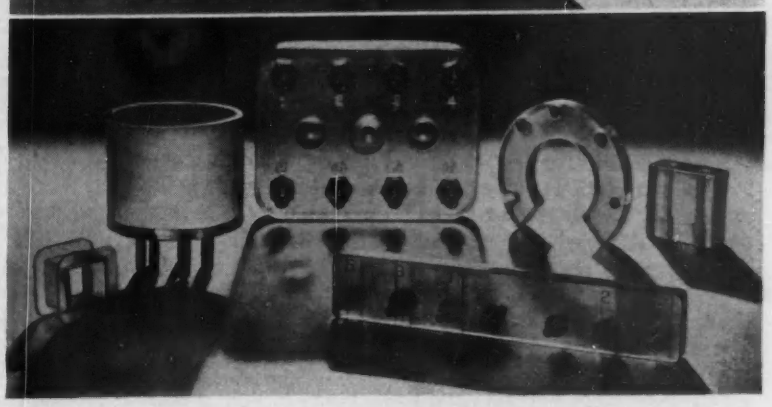
Other problems of the lumber industry are engaging the attention of the organic chemist. For instance, he is aiming at devising a "rot-proofing" treatment, as well as a fire-retardant treatment. Real progress has been made in both directions. The prediction is that within the next generation, lumber that is resistant to both fire and rot will be in wide use. Thus one of man's oldest materials of construction will be better adapted to meet the exacting specifications of modern engineering.

Skipping now to the mining industry, again we find the organic chemist busily engaged applying his skills. As everyone knows, the mineral resources of a nation are measured by the "values" that can be recovered economically rather than by an absolute assay. So it was that a few years ago, the low-grade copper ores containing one per cent or less of copper were uneconomic. Today, however, such ores are worked profitably, thanks to the aid of minute proportions of organic chemicals known as frothing agents and collectors. When

(*Continued on page 52*)

— *Courtesy Industrial and Engineering Chemistry.*





Some examples of uses for modern plastics.

Low-Income Housing

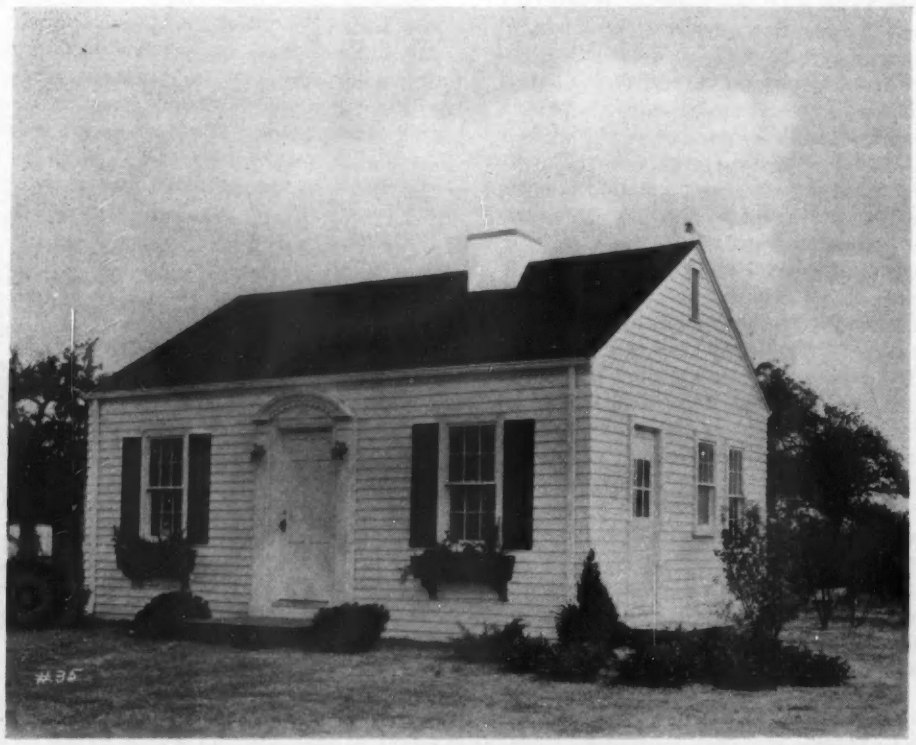
The Government at Work to Save the Small Home-Owner

PETER GRIMM

HOUSING, like so many general terms, is a word of many meanings. It is used in the social sense by some, in the economic or financial by others, and by still others in the engineering or the artistic sense. That accounts in part for the confusion about the activities of the United States Government in the field of housing. My purpose is to attempt to clear this up.

Confusion is caused at times quite incidentally. For example, the recently enacted Wagner-Steagall Bill created the United States Housing Authority, setting up its head with the title of United States Housing Administrator, although there is already the Federal Housing Administration with its head, the Federal Housing Administrator. The two bodies are constantly confused even by well informed reporters. Let us see if we cannot get a bit more clearly the picture of what the Federal Government is doing in the various fields.

There is the Home Owners' Loan Corporation, one of the earliest Federal agencies set up by Congress. It was created for the purpose of saving the homes of this country. This agency finances first mortgages on homes where the home owner is not able to procure such credit through the usual lending institutions. The limit is $14,000 in each case. The H.O.L.C. gets its funds through the issuance of Home Loan Bank Bonds, which are sold in the usual way to the public. For example, on the very day on which I am writing, I see in the financial pages of the New York newspapers the announcement by the Home Loan Bank Board of the offering of $25,000,000 of its bonds. These were being offered for three years on a 1⅞% basis; these terms speak well of the estimate in which they are held by the public. Indeed, the operations of the H.O.L.C., the manner in which it came to the rescue of the small home owner and the way in which its vast financing was conducted is a tribute to John H. Fahey, the Administrator, and to his associates on the Home Loan Bank Board. The vastness of its business will be indicated when I tell you that they made somewhat in excess of one million individual mortgages and that the total of the money invested in these mortgages was somewhat more than three billion dollars. In contradistinction with the Federal Housing Administration, of which I shall now tell you, the H.O.L.C. lends money directly on mortgage. It does this by exchanging its bonds, which are liquid, for frozen mortgages on homes.



— *Courtesy Architectural Forum.*

Steel frame prefabricated house for FHA.

The Federal Housing Administration, headed by Stewart McDonald, lends no money at any time or in any place. Its main business is to stimulate the financing of homes and the construction of new homes by the use of private funds. This it does by the use of Federal credit. It uses this by putting the stamp of insurance of the United States Government on loans that are approved, thus guaranteeing to the private mortgagees the safety of the principal invested. The limit in individual cases is $16,000. Up to a year ago, F.H.A. also insured remodeling and renovating operations on homes up to a total in individual cases of $2,000. It also insured remodeling and additions to properties like apartment houses, hotels,

hospitals, schools, industrial plants, up to $50,000, but all insurance on remodelling and alteration jobs was withdrawn after the work in this field had served the purpose. F.H.A. also insures multiple dwellings, that is, apartment houses and row houses, a much larger field in which it has made a creditable start and will doubtless develop even greater activity as the work goes on. Thus the Federal Housing Administration has done an excellent job of administering the National Housing Act. It has insured somewhat over $1,000,000,000 of individual loans on private houses, which means that some 300,000 home owners have been able to get mortgage money at a time when it was difficult to get such financing. It insured over $560,000,000 of alteration work. This has been a solid substantial business, involving small cost to the Government. To date, only fifty foreclosures have been necessary with the loss to the Government of only some $10,000.

The important thing to remember here is that F.H.A. lends no money at all, it only insures approved loans made by private institutions in the lending field such as savings banks, mortgage institutions, life insurance companies, building and loan associations, and the like.

Then there was the Housing Section of the Public Works Administration of the Interior Department, generally known as P.W.A, headed by Harold L. Ickes. This agency began its work in 1933, since which time it has built some fifty large units and spent about $135,000,000. Most of these buildings are completed, some are occupied and others are near completion. It also directed and supervised the creation of some seven additional large scale apartment dwellings through what is known as Limited Dividend Corporations. One such operation, located in New York City and known as Hillside Homes, is managed by my firm and I will later tell in detail about this work.

Earlier, before P.W.A. was well started, the Reconstruction Finance Corporation financed Limited Dividend operations of which Knickerbocker Village, a large scale apartment house construction, comprising 5,237 rooms and 1,587 baths, also located in New York City, is a type.

In these Limited Dividend operations the Government supplies the funds necessary to build, generally about eighty-five per cent of the sum total of the value of the land and cost of the improvement. The money is lent on long mortgage at about 5% interest. The Government closely checks and approves the plans and construction, and throughout the life of the operation supervises and has an important voice in the management. The principle of the Limited Dividend Corporation, stated simply, is that in consideration of the money advanced by the Government, the corporation undertakes to provide dwellings at a rent not to exceed a fixed amount (usually from $10.00 to $12.50 per room per month), the corporation further agreeing to limit itself to a 6% return on the value of its equity or investment, if earned. All sums earned in excess of the 6% are paid to retire the mortgage.

There are many other Federal agencies in the housing field, but their discussion is not important, for the purpose of this

(*Continued on page 50*)

A street in Buckingham (not Federal housing). Urban conveniences combined with spacious parking areas create a new and improved pattern for rental housing.

— Courtesy Architectural Record

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Editorials

TOP OF THE BOTTLE

MASSACHUSETTS manufacturers have paid little attention to the extremely valuable production of domestic material which is dumped on the market each year in June when commencement days come and the graduates of our leading institutions start out into the work-a-day world.

Massachusetts, as a manufacturing state, leads the Nation in woolen and worsted textiles; in boots, shoes and footwear; in machine tools, precision tools; in heavy machinery; in toys; in electrical equipment; in plastics; in silverware, and in industrial chemicals, all of which pioneered in Massachusetts and are still carrying our industrial leadership around the world. At the same time, Massachusetts abounds in universities and scientific institutions without equal anywhere in the United States.

But nearby manufacturers seldom look to nearby institutions for young men to train and to bear the executive and engineering burdens of industry ten years from now, whereas national industrial concerns send their traveling executives with attractive offers to these self-same graduates into far-flung fields. At best we have been prone to see the large outside corporations skim the cream from the top of the bottle of Massachusetts graduating classes.

Yet the college graduate, and particularly the engineering school man, is a person of considerable value to the local industries. He is alert, ambitious, and possesses a keen, analytical mind, born of four years rigorous training in engineering and applied science.

How to bring these two forces together? The Associated Industries of Massachusetts on its part is continually urging manufacturers of the state to see that Massachusetts' graduates enter Massachusetts industries where there is room for the best trained men right here at home.

What can the graduate do to help in this movement? First and foremost, he should learn how to sell to industry his college training by analyzing his own accomplishments, ambitions, and natural tendencies which have come to the surface in the intensive training just finished, (avoiding of course hobby interests which should be kept avocational). Once knowing his natural aptitude for a certain type of business or industry, and fortified with institutional training at its best, he can then search out the local possibilities, call on certain companies and through personnel channels submit his aptitude, his training, and his desire to work in that particular business. Too often a college graduate merely applies for the nearest or easiest job instead of matching his training and natural aptitude to the available job.

Hundreds of college men come to the attention of the writer looking for jobs — and just that, looking for jobs — instead of first studying their own qualifications and then searching the market to match same. The writer recalls two examples not of this class out of many known to him: a young man graduating from Tufts College, majoring in chemistry and preparing his thesis on rubber, found both training and natural inclination in this field. Hood Rubber Company was nearby in Watertown, an application was made, qualifications stated, and the job received. Another applicant, of Boston University and Harvard Law School training, matched his

law work to natural interest in industrial problems, laid these dual qualifications before an industrial group and is now legislative counsel thereof.

To the industries of this Commonwealth, the Massachusetts-trained graduates offer ideas born of learning, the enthusiasm of youth, and the expert training of our universities. And to the student now looking for an opening after graduation, the manufacturing plants of Massachusetts offer proving grounds for their talents and a challenge to carry Massachusetts leadership to greater heights than ever before.

ROY F. WILLIAMS,
General Manager,
Associated Industries of Massachusetts.

INSTITUTE COMMITTEE

THE recent actions of the Institute Committee in threatening to withdraw recognition of various class B activities and to reduce the representation of the lower classes on the Committee have been ill-considered and unjustified.

As a result of these moves the respect of the undergraduates toward the Institute Committee has greatly diminished. Not once within the last three or four years has this Committee fallen into such disrepute. That the Beaver Club would jokingly or seriously mention an investigation of the Committee is positive proof of the light in which that body is held.

An Institute Committee meeting is no place for the Budget Committee to discipline neglectful activities, although doubtless these activities had to be stirred from their lethargy. In its purpose and result the Budget Committee was justified; however, the effect of the means to this end upon the Institute Committee should have been considered. Again the move to reduce the representation of the lower classes on the Institute Committee might have been intended to arouse the interest of the lower classes in the Committee. The aim was worthy, but the effect has been unfortunate.

The worst part of these incidents is the effect that they might have on succeeding Institute Committees. The loss of face of one group is bequeathed to the next. Any Institute Committee which hopes to make a worthwhile contribution to undergraduate life must have the respect of the student body.

The best that the present Committee can do is to try to remove the handicap that it is leaving for next year's body.

NAPOLEON "II"?

THE recent actions of Adolf Hitler give reason to wonder if the title "Napoleon" should not be given to him. Napoleon was, as Hitler is, a vain, selfish, egoist, who thought that he could unite all of Europe under his rule. Guessing doesn't do any good, but Hitler seems to be emulating Napoleon in many things, with perhaps the intention of satisfying the desire of many little men: that they may someday rule the world.

If history repeats itself, we are likely to see another World War — brought about, as were the Napoleonic Wars, by the over-weening ambition of one man. It is certain that France will never let Germany become the dominant power in Europe, even though the two nations were once united in the Holy Roman Empire.

The former Kaiser, even when he was at the zenith of his power, did not attempt to annex Austria as a vassal estate of Germany.

With Austria in his possession, and his position there consolidated, where will Hitler move next? England and France look toward Czechoslovakia as the probable focus of his next attack. Have they considered the possibility of his evincing a sudden desire for Hungary, since it was a part, although a reluctant one, of the old Austria? In any case, as Professor Fay of Harvard points out, Hitler can not do much else until he finishes the reorganization of Austria.

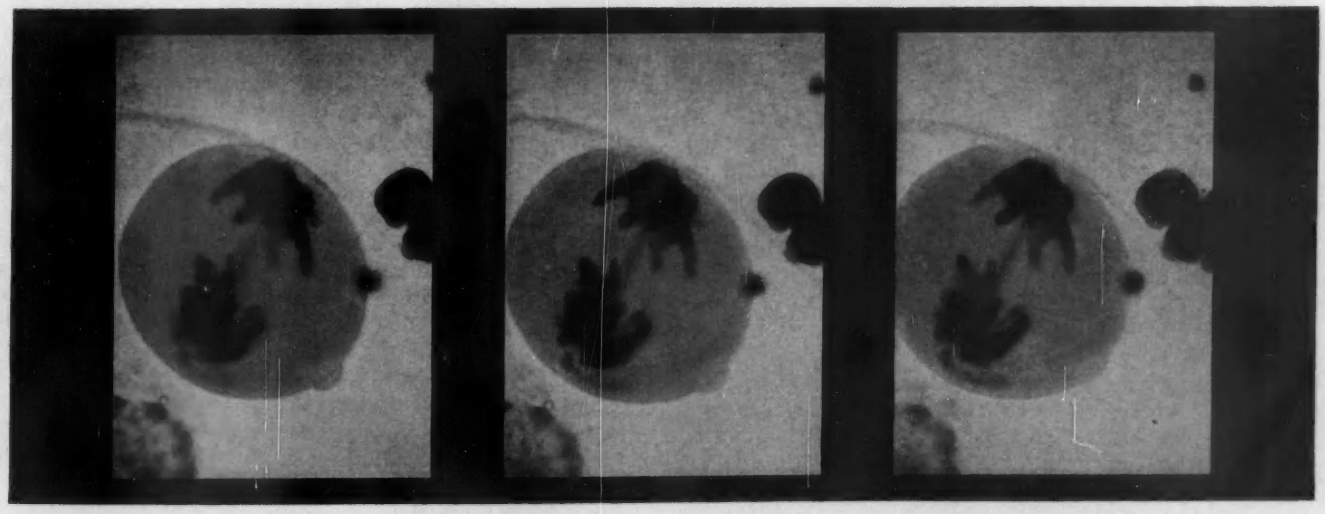
The only question is: Does Der Führer feel so bloated with power that he will try to take on two jobs at once, and so draw down on himself the armed wrath of France, and Russia? An answer to that question, backed up by good evidence that it is correct, would be welcomed by the Chancelories of the world.

When the organization of Austria is completed, there will be a complete Nazification of the country, with its attendant Jew-baiting, and persecutions. Even the Pope in Rome is worried about the final outcome of this new move, which brings Nazism into one of the most strongly Catholic countries in Europe. Already the Jewish lawyers have been disbarred, and some of the doctors prevented from carrying on their practices.

England, France, and the United States are the leaders to which the rest of the world look for guidance in this crisis, and these three nations are powerless to stop Hitler by any means other than armed conflict, unless previous experiences are misleading.

That living cells are colloidal is illustrated in these remarkable photographs (1200-X), showing the dividing nucleus in three optical sections.

— Courtesy Technology Review — Francis F. Lucas.



RESEARCH IN REVIEW

COURSE XII — Mineral Orientation in Rocks

RESEARCH work in Structural Petrology is at present being conducted by Professor H. W. Fairbairn of the Department of Geology. Although investigations of this character are carried on at relatively few schools, their value is apparent in many branches of the science.

The orientation of the minerals of which a rock is composed is directly related to the origin of the rock. The orientation may be indicated by the shapes of the mineral grains, by the arrangement of their crystal lattices, or by both. The former (dimensional orientation) may be studied with the naked eye or with the standard petrographic microscope; the latter (lattice orientation) requires special apparatus. For medium or coarse-grained rocks a miniature theodolite is mounted on the microscope stage, and an oriented thin section of the rock is placed at the intersection of its three axes. By suitable manipulation the crystallographic orientation of the minerals in the thin section can be determined, and the data can be plotted on a standard projection. The statistical pattern shown on the projection is correlated with structures and textures seen in the field, and the combined data give the structural history of the rock. This phase of mineral orientation has been carried on for almost fifteen years, at first only in Austria and Germany, now in a number of countries, including the United States and Canada.

For very fine-grained rocks such as slate, an X-ray technique was developed in Austria by Sander less than ten years ago. A fine-grained rock is simply a cemented mineral powder, and a thin plate of it placed in the path of an X-ray beam produces reflections which lie as a series of concentric rings on a flat film. The mineral orientation is indicated by unequal blackening of the rings. The photographs are correlated with visible textures and structures, and an attempt is made to decipher the history of the rock.

For X-ray study of coarse-grained rocks a scanning camera has recently been built by Mr. Von der Heyde in the departmental shop. A simple mechanism moves the flat face of a small specimen through the path of the beam in parallel position. In this way a sufficient number of grains cross the path of the beam to give a statistical ring pattern which is similar to that for a slate. It is hoped that this method will have wide enough application to eliminate much of the laborious microscope work at present necessary. The work of preparing specimens will also be shortened if the back-reflection X-ray method is found applicable.

COURSE II — Turbine Research

PROVIDING a more efficient means of answering the mechanical engineering problems of turbine design has required the recent services of an astrophysicist, and a chemical and mechanical engineer. The result of their efforts is a blueprint chart, thirty inches wide and fifteen feet long, cross hatched with a maze of lines and beautifully drawn curves. This, an enthaipy-entropy chart based on the "Thermodynamic Properties of Steam" published last year by Professors J. H. Keenan and F. G. Keyes, mechanical engineer and chemist, respectively, of the Institute, was accomplished under their supervision by Dr. Carol Anger Rieke. Pressures are plotted against temperatures on the chart for use in the design of large low-pressure turbines. By incorporating the data from the Keenan-Keyes steam tables this chart avoids the necessity of interpolation to determine the desired figure. After the data from the tables had been plotted, Dr. Rieke accomplished the delicate task of laying off the long sweeping curves with the aid of naval draftsman's splines.

Sponsoring the project were the Allis-Chalmers Mfg. Co., Westinghouse Electric & Mfg. Co. and General Electric Co., present custodians of the chart.

Another smaller chart—20 inches by eight feet—accurately indicates how much steam must be put through a perfect turbine to secure one kilowatt hour from it. This chart, a theoretical steam rate table, shows pressures from zero to 3000 pounds per square inch and temperatures to 1000 degrees Fahrenheit. The American Society of Mechanical Engineers is publishing this table at the request of the sponsors.

COURSE V — Equipotential Solutions

THE chemical potential of a substance is a measure of its tendency to transfer from one phase to another or to react chemically. In gases the change of potential with concentration may be determined by measuring the pressure. In some liquid solutions, the potential of a solute may be determined from its vapor pressure; in some others, it may be related to the electrical potential developed between suitable electrodes placed in the solution. More often, however, the chemical potential of the solute must be calculated from that of the solvent. This calculation is such that the error in the potential of the solvent is multiplied by the ratio of the number of moles of solvent to that of the solute. Consequently, the measurements must be very accurate, especially in dilute solutions.

One of the most accurate methods of measuring the potential of the solvent in dilute solutions is by means of the freezing point depression. In the Research Laboratory of Physical Chemistry the depression of the freezing point in dilute solutions has been measured to an accuracy of 0.00002° C., which corresponds to an accuracy of one part in five million in the vapor pressure. This would require a temperature control of 0.000006° C. if measured directly. The disadvantage of this method is that the results are obtained only at the freezing temperature, which of course varies with the concentration.

Direct vapor pressure measurements are too inaccurate for very dilute solutions but become more accurate as the concentration increases. However, a very accurate method has been developed in recent years to compare the concentrations of several solutions which have the same potential of the solvent, but it is limited to those solutions which have non-volatile solutes. Of course, this is not a serious limitation. Such solutions may be called equipotential solutions. Small samples of two or more solutions are placed in an evacuated cell at a constant temperature and the solvent is allowed to distill from one solution to another until its potential is the same in every solution. If the composition of the original solutions and the original and final weights of the samples are known, the composition of the equipotential solutions may be calculated.

It is then necessary to know the potential of one of the solutions accurately to determine that of the other solutions, and this was our first task. Aqueous solutions of sodium chloride, potassium chloride, sulfuric acid, sucrose, urea, and glycerine

have been used, and the measurements have been carried out at 25° C. These substances were chosen because their solutions have been studied more than any others, and their potentials have been more accurately determined. Fifteen series of measurements of the potential have been used, obtained by almost as many methods. The concentrations of the equipotential solutions have been determined from saturation of the solid substances down to 0.1 molal sodium chloride. By comparison of the fifteen sets of data through the results of this research, values of the potential of the water have been very accurately determined. The average deviation of the value of the potential in dilute solutions thus determined, corresponds to an accuracy of one part in one hundred thousand in the vapor pressure.

The apparatus also lends itself easily to the accurate determination of the solubility of solid substances without the necessity of separating the two phases. A large excess of the solid is added to one of two samples of its nearly saturated solution. In the process of equalizing the chemical potential the two solutions attain the same concentration. At equilibrium both solutions will be saturated, and the composition of the saturated solution may be calculated as before from the weight of the sample which has no excess solid.

COURSE I — Structures Research

THE new Structural Analysis Laboratory which was opened this year in the Department of Civil and Sanitary Engineering has aims which are both educational and scientific. By providing facilities for research by staff members as well as by students, progress along both lines has been made.

The work which has been carried out so far may be divided into two general fields: investigation into structural action so that current structural theories may be checked and in some cases modified; and the study of methods of model analysis whereby long mathematical analyses can be avoided through the interpretation of the action of structural models.

About half of the work is done with metal models, steel, duralumin, and brass being commonly used. For other approaches, plastics are used; celluloid and bakelite are especially convenient.

Mr. A. R. Anderson is engaged at present in an investigation of the influence of secondary factors which affect the stiffness of trusses. He is working with duralumin models and a testing machine specially devised for the problem, to determine separately the stiffness of trusses due to rigid joints, gusset plates, lacing bars, lateral systems, portals, stringers, and roadway slabs. The combined effect of these factors is sufficiently great to have practical importance in connection with the computation of truss deflections.

Mr. W. M. Bjork has initiated an investigation of the accuracy of theoretical methods of computing deflections of beams, considering distortions due to both bending and shear. He is also making preliminary studies of stress distribution in bakelite models carrying bending moment and shear, by means of polarized light. The laboratory is equipped with a unique testing machine for this purpose, which, by using large polaroid disks for polarizing light, makes possible the investigation of stress distribution in relatively large models. The investigation of stresses in gusset plates is the general problem toward which Mr. Bjork is working.

Mr. Johann Meier is investigating the deflection of beams due to shear. Studies on celluloid models have already verified theoretical analyses of the distortion of transverse cross sections due to shear, and the polarized light method is now being used in continuing the research.

Mr. G. C. Green is investigating stresses and deflections in thin rectangular plates supported on four sides.

Mr. E. O. Schmidt has completed the development of a method whereby secondary stresses in trusses may be determined by truss models of celluloid. The development of a celluloid spring balance which compensates for creep in celluloid, and the building of a new moment indicator which magnifies the readings taken, constituted major problems in this project. It is believed that secondary moments in trusses have never before been determined by model studies.

Mr. B. Boguslavsky is developing a new method of model analysis for rigid frame structures. Working with celluloid models, a new type of instrument has been devised. Preliminary tests have been encouraging, and there is reason to hope that the new method may be of considerable value.

Mr. H. P. Mittet is investigating the relative merits of model analysis by means of the Beggs Method and by means of the M.I.T. Moment Indicator. His tests are being conducted on a celluloid model of a building frame which is statically indeterminate to the 36th degree.

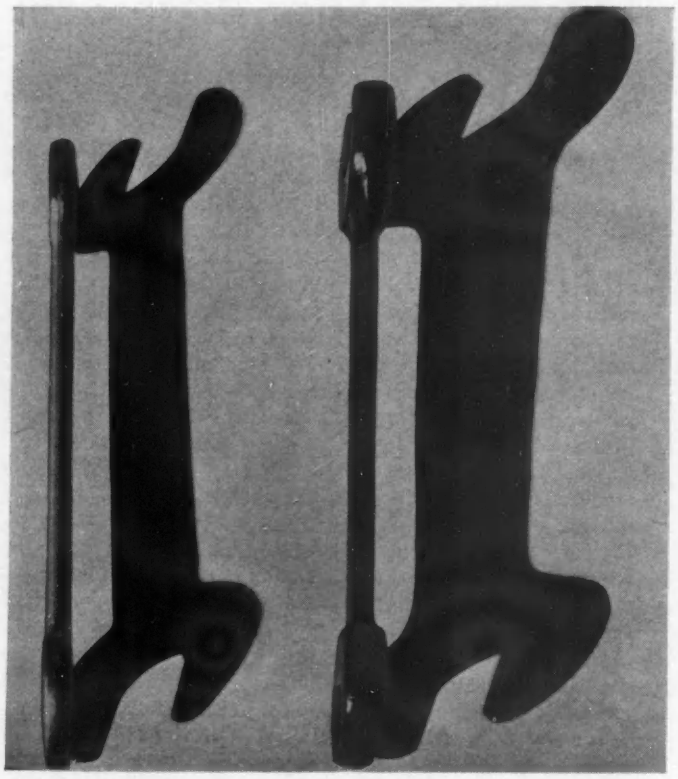
Messrs. W. C. McClure and J. W. Greely have completed a model of the Ambassador Suspension Bridge at Detroit. They are about to measure stresses in the model under various conditions of loading, for the purpose of investigating the relative accuracy of the elastic theory and the deflection theory of suspension bridges.

(*Continued on page 51*)

— *Courtesy Technology Review.*

In the new structural analysis laboratory.

ENGINEERING DIGEST



ALLOY STEELS

DESPITE automatic machinery and countless mechanical devices which recent years have made available to industry, hand tools are still among man's most useful implements. Even in highly mechanized manufacturing they are indispensible for many operations. Moreover, it is hard to imagine any household getting along without the aid of a hammer, a screw-driver, and a wrench or two.

While there have been many changes in design, needs for improvement have become more and more marked as modern developments have placed greater burdens on tools. Wrenches, for example, are called upon to perform all sorts of work, often the kind for which they were never designed. Obviously they must be strong. Most of them are made of either forged or cast steel, materials which, in unalloyed form, can be made strong by control of carbon content, but which tend to become more brittle as the strength and hardness content is raised. In the past the remedy was to compensate for lack of toughness by increased weight and bulk. Disadvantages of this method are apparent.

Wrench manufacturers have now begun to experiment with alloy steels, employing nickel and like elements, in an effort to increase strength and at the same time decrease weight and bulk.

Today in custom-built wrenches a 3½ percent nickel steel or a 1 to 2 percent nickel chromium steel is usually employed. Brittleness is almost completely lacking in these steels. For standard wrenches of open-end or box type in smaller sizes, a nickel molybdenum steel with a nickel content of from 1.65 to 2.00 percent is gradually replacing older materials.

In some of the experiments, which led to the selection of this alloy-box socket, wrenches were employed. They were used as hammers and then squeezed in a vise in an effort to collapse the heads. In tests designed to simulate actual working conditions, they were used to twist heads off the highest strength heat treated alloy steel bolts available. While making a breakdown test, one of these bolts was held in the jaws of a torsion testing machine equipped with an indicating device to show leverage applied. The nickel molybdenum steel test wrenches withstood torsion about 35 percent higher than similar wrenches of competing steels. In every type of tool the manufacturer is beginning to realize the advantages of alloy steels over carbon content steels. They afford a better plastic range, they are strong and light in weight, but yet not brittle nor liable to fracture.

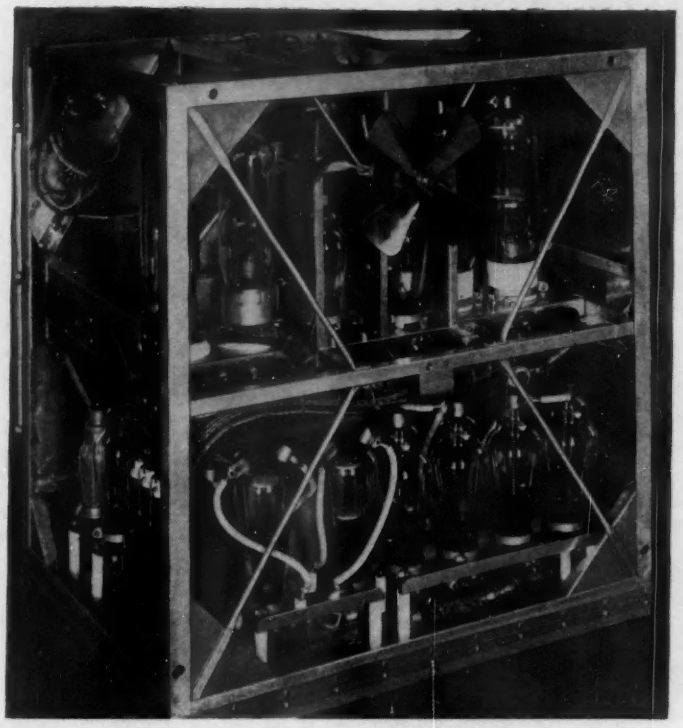
—*Inco*

STAINLESS STEEL PLANT DOUBLES CAPACITY

STAINLESS steel, the jewelry item of the steel industry, is unique in there being one plant in the world that takes the crude chrome ore from Turkey and India, runs it through the melting and various shaping processes, and produces the final product, stainless steel.

This plant, belonging to The Rustless Iron and Steel Corporation of Baltimore, Md., has just had a $1,500,000 addition which doubled the plant's capacity, till now it produces 40,000 tons of ingots and 12,000 tons of various other forms of stainless steel.

Stainless steel is a combination of chromium and iron, the iron being added to the crude chrome ore during the smelting processes. From the furnaces the ingots travel to the blooming mills and emerge as billets, semi-finished



forms of steel. Further rolling produces rods of any required shape or size.

The processes are interesting from the point of view of the care that is exercised in maintaining the high quality of the steel. A highly trained staff of metallurgists is on duty at all times to oversee the work and inspect the steel at various stages. Their work is not ended when the finished product is produced, however, as it must be tested for ductility, toughness, "hardenability," and various other physical properties. And, of course, research is being continually conducted, looking for possible improvements in the steel and new uses to which it can be put.

The stainless steel industry is small, averaging around 95,000 tons of ingot per year, but it is all important in the part it plays to stem the inroads of corrosion, estimated to amount to $3,000,000,000 yearly.

—Wire & Wire Products

ALUMINUM ALLOY STRUCTURAL MATERIALS

ALUMINUM and aluminum alloys are becoming a very important factor in many industries of our country today, and along with others, the Bell Telephone System is extending its use of these materials. Steel, brass, and bronze have been replaced by aluminum in many cases where light weight is important, or where lower costs or increased efficiency result from its use. The adoption of sheet aluminum alloys for diaphragms in receivers and transmitters has made possible a higher standard of voice quality and operating efficiency than was attainable with other common metals. Many parts for telephone apparatus are now diecast from aluminum alloys.

These alloys are especially useful in equipment where maximum mechanical strength with a minimum of weight is required. Even though the cost of aluminum alloy per pound is five times that of steel, they have approximately equal strengths and elongations, and corresponding aluminum parts weight only one-third as much. If light weight alone is desired, and the strength of the metal is not of major importance, an alloy of aluminum which does not react to heat treatment may serve the purpose. The latter alloys are only slightly more expensive than steel from the standpoint of volume. Structural parts made of aluminum alloys are becoming standardized. Hundreds of special shapes are made in addition to wood and machine screws, nuts, washers, rivets, nails, and bolts. Wire, rod, bar, strip, sheet, tubing, and pipe-fittings are also obtainable in their standard sizes.

Finish and corrosion are very important factors to be considered in selecting an alloy. From the viewpoint of corrosion, aluminum and aluminum alloys are generally far superior to steel. In many cases, the product has sufficient finish when it leaves the manufacturer. Substitution of aluminum materials for those which require a protective finish producing a considerable saving.

Aluminum has its limitations, but the fact still remains that it is steadily pushing itself forward into wider use as new and improved alloys are developed. An illustration of the use of the new alloys is shown in the accompanying photographs.

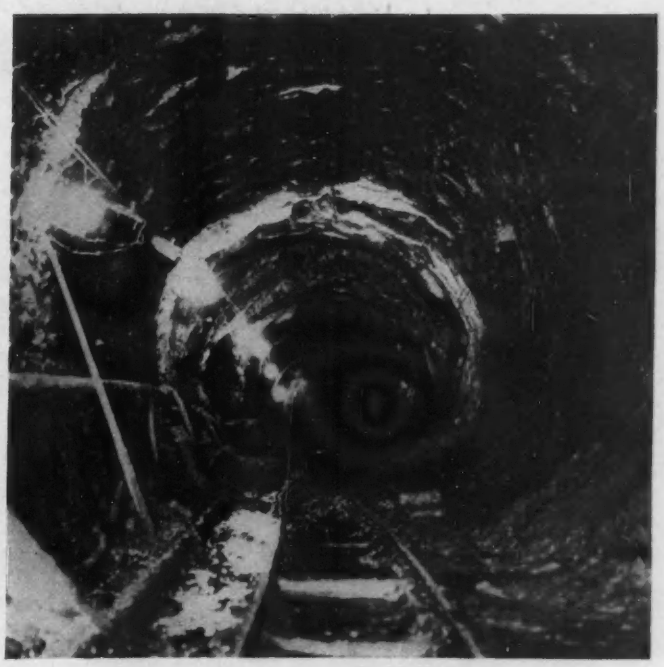
—Bell Laboratories Record

RALSTON CREEK DAM

THE Moffat Tunnel Extension Project is one of the important flood-control projects under construction at the present time. It was necessary to construct a great storage reservoir somewhere on the eastern side of the Continental Divide in order to bring western slope water into Denver. A site in the foothills 12 miles west of Denver on Ralston Creek was selected for this reservoir. The Ralston Dam is earth-filled, and is one of the greatest heaps of rock and earth that man has ever piled up in so short a time.

Thus we see that men have made it possible to bring water from the Fraser River Basin, across the Continental Divide, through the rough country from South Boulder Creek, over an extension plateau of a sandy, permeable combination into the City of Denver, by way of the Ralston Reservoir, without the necessity of pumping at any point along the line.

—Explosives Engineer



THIS HALF-SEEING WORLD

(*Continued from page 35*)

No longer are we satisfied merely to see. The goal is at least to see easily and with certainty. We now know that for reading large print on white paper (which can be read in the moonlight) the ideal intensity of illumination is above 100 footcandles. At a convenient distance from a bridge lamp containing a 100-watt lamp, one may obtain 100 footcandles. Still most persons read under less than 5 footcandles, and 5 footcandles are the exception throughout the work-world.

The science of seeing also determines the difficulty of visual tasks. It shows that for sewing on dark goods we require many times more light than for reading with maximum ease. The best available light for sewing with black thread on dark goods is in the direct light of the sun. This means thousands of footcandles. If we ask a lighting specialist to supply us with such intensities of illumination, he cannot do it. Thus, we are in no danger of having too much light. In our artificial world it is impracticable to obtain too much light if the lighting is proper. These two tasks represent extremes in difficulty—reading large print on good white paper and sewing with black thread on dark goods. Between these two extremes are many tasks of all degrees of difficulty. If reading is done with the greatest ease under more than 100 footcandles, it is obvious that most other serious tasks, which are generally more difficult, should have more light than this. Still, throughout the entire factory world, only a few footcandles are found. If we conservatively recommend 20 footcandles for reading, we must specify 50, 100, 200, and 500 footcandles for other tasks. In our schools and libraries, where young eyes are becoming introduced to the slavery of the unnaturally close, prolonged, and severe visual tasks of civilization, they too are supplied with only a few footcandles. And in the homes they are also penalized in the same manner.

In our stores we find a few footcandles on china and stationery which reflect light well, and usually lesser intensities on floor coverings which we want to see before we buy. Carpets and rugs thirst for light, for they are dark, their colors are subdued, and the light is lost in the nap. If 10 footcandles can be justified in china and stationery, 100 to 200 footcandles at least are necessary for properly seeing carpets, men's clothing, and other dark textiles.

The science of seeing has introduced the idea of ease of seeing. It has also introduced new concepts of speed and certainty, which are of vital interest wherever safety depends upon seeing. Now let us drive an automobile. Here, as in every other phase of seeing, the science of seeing has introduced new concepts. Even though the operation of the automobile may seem automatic, it is reducing one's ability as a seeing-machine. Some of the driver's total ability or sense capacity is being used for operating the automobile. Useless noises further reduce his ability. He is also alert to noises, as he approaches an intersection, which serve as warnings of approaching vehicles. This further reduces his ability as a seeing-machine. He passes a stop-sign which is not self-luminous. A traffic officer notices this and crowds him to the curb. "Can't you see the sign?" he says. Of course, the driver can see it now, because he knows where it is, has nothing else to do, and has an incentive to see it. The visibility of that stop-sign is now high, but a moment before it was not. The driver was not only a seeing-machine of greatly reduced ability, but the non-luminous stop-sign was merely a part of a visual field full of haphazard colors and patterns. The only practical solution is to make the sign more visible by making it self-luminous. This raises it far above the brightness of the surroundings. One seldom misses a self-luminous traffic signal. Its brightness is of high key compared with the surroundings. If courts rendered verdicts based upon the science of seeing, convictions would be impossible in such cases.

While on the subject of automobile driving, we might recall how much more tightly we grip the wheel at night on a poorly-lighted street than on a well-lighted one. Then recall a fog. How glad we are to stop after an hour's drive in a fog when seeing is poor. Such cases are the extreme ones which demonstrate that seeing causes nervous muscular tension. But that is a penalty always being paid for seeing, whether or not we are conscious of it. Combined with many other recently discovered psychophysiological effects of seeing, startling pathological implications are being revealed by this science of seeing. These are examples of the contributions of the science of seeing, which deals with ease of seeing instead

(*Continued on page 49*)

SAMSON SPOT SASH CORD

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Made of extra quality cotton yarn, carefully inspected, and guaranteed free from all imperfections of braid or finish.
The colored spots are our trade-mark, used only with this quality.
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POLAROID

(*Continued from page 38*)

accomplished commercially no other way. Utilizing the above principles one may arrange many striking advertising displays and realize color combinations that have never before been produced. Static signs may be made to appear motivated by the very motion of the observer. As the pedestrian moves, the color combinations of the sign appear to him to be varying, so that at any angle the onlooker views a different color arrangement. Thus, of a crowd of people, no two observers see the identical combination of colors, since each person is viewing the display from a unique position.

The final step of the motion picture in bringing real life to the screen is the production of three-dimensional movies. Polaroid has already facilitated this feat. It is well known that the right and the left eyes always view a scene from slightly different angles—a fact illustrated by noticing how the fingers of the outstretched hand appear to move across the scene as they are viewed first by one eye and then the other. If two photographic images of such views are projected one over the other, the right-eye view polarized in one plane and the left-eye view polarized in a plane at right angles to it, observers will see the scene as a solid three-dimensional picture if they look through Polaroid spectacles with the "slots" of the right and left lenses arranged to correspond. The same principle may be utilized for museums, viewing boxes for salesmen, advertisers, and X-ray workers.

When some transparent substances like glass and quartz are subjected to strains or stress, they develop certain birefringent characteristics, which become visible to the eye when the material is placed in the path of polarized light (*Tech Engineering News*, 17:118, October 1936). At present there are photo-elastic methods of producing "strain maps" of these objects, but because of the difficulty of obtaining polarized light, this method of studying strains and stresses is limited. With the advent of Polaroid, large beams of polarized light may be inexpensively produced. If scale models of constructions are built of a transparent substance like Bakelite, the stresses and strains that will be encountered in the actual construction can be studied in a relatively quick time and with exact results (cover). Using a photo-elastic polarizer and contour projector which utilizes Polaroid one can, for example, *see* how a bridge will react to various loads before construction of the bridge is initiated.

The uses, scientific and commercial, to which this new and inexpensive polarizer can be put are countless. It has actually opened a new industry and new fields of research. In time, it will undoubtedly be instrumental in many remarkable discoveries and innovations.

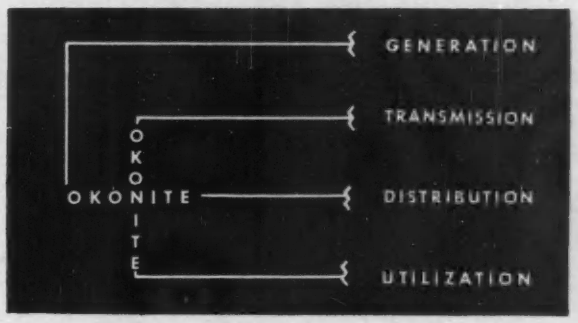
THIS HALF-SEEING WORLD

(*Continued from page 48*)

of merely threshold visibility as the science of eyes or vision does.

The science of seeing not only shows how much light should be provided, but also what kind of light and lighting is necessary. It is revolutionizing not only lighting, but also many other aspects of seeing. It is showing that this artificial world needs not only lighting specialists and eye specialists, but seeing specialists as well. Human seeing-machines are everywhere wasting valuable resources. Some of this waste is obvious as in accidents and spoiled work. Millions work at unnatural tasks under unnatural conditions daily, and then go home to read or to sew for recreation, further penalizing themselves. Most of this waste goes unnoticed, and its effects are delayed. The science of seeing reveals new horizons beyond which may lurk newly suspected penalties in undermined health, and possibly even more startling ones.

THE 4-Ø ELECTRICAL SYSTEM



Okonite Wires and Cables are designed for every condition of use in each of these phases of any electrical system.

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LOW-INCOME HOUSING

(*Continued from page 41*)

article. One, however, should be mentioned, although its activities have largely come to an end. That is the Resettlement Administration, which was a merger of the Rural Resettlement Division and Subsistence Homesteads Division. That agency, under the head of Rexford G. Tugwell, was much in the public press and was for some three years very active. The value of its contribution to the solution of the housing problem of this country, however, is much in doubt. It operated in the field of providing homes in rural and suburban areas, where it developed what was called "Green Belt" or ideal communities. It was planned to make these communities self-sufficient by resettling large groups of individuals from places where they were in need and out of work, to communities where industries and homes were created by the Government.

The United States Housing Authority, under Nathan Straus, Administrator, administers the Wagner-Steagall Act. It may help to think of this Authority as the successor of P.W.A. In fact, the entire operations of P.W.A. were, by the Act, turned over to the United States Housing Authority. Administrator Straus is now in the process of a study of these housing demonstrations and experiments set up by P.W.A., and after the lessons taught by these are digested and understood and the rents finally fixed and the apartments tenanted, the Administrator will doubtless proceed with the larger work directed by the Wagner-Steagall Bill.

This Authority has, in the words of the Act, the purpose "to provide financial assistance to the States and political sub-divisions thereof for the elimination of unsafe and unsanitary housing conditions, for the eradication of slums, for the provision of decent, safe, sanitary dwellings for families of low-income and for the rejection of unemployment and the stimulation of business activity." For this purpose the Congress authorized the Authority to issue obligations in the form of notes, bonds or otherwise, in the sum of $500,000,000 to obtain funds. The Authority may issue $100,000,000 in such obligations up to July 1, 1938, an additional $200,000,000 on or after July 1, 1938, and an additional $200,000,000 on or after July 1, 1939. Not more than ten per cent of the funds so raised may be expended in any one State.

The grant is payable in the form of fixed and uniform annual payments over á priod which may not exceed sixty years. The amount of the grant in any one year may not exceed the yield which is current on Federal bonds at the time the contract is made, plus 1%, on a principal sum equal to the development or acquisition cost of the project.

Among the more important provisions of the Act is the safeguard against excessive cost of construction. The provision is that public housing agencies receiving funds from this Authority may not incur a construction cost of more than $4,000 per dwelling unit, or not more than $1,000 per room, in cities of less than 500,000 population, and $5,000 per dwelling unit, or more than $1,250 per room, in cities of over 500,000 population.

In order that public housing so created shall reach the low-income groups for which it is intended, the Act provides that "low-income families are those which cannot afford to pay enough to cause private enterprise in their locality or metropolitan area to build an adequate supply of decent and sanitary dwellings." The Act then goes on to provide that public housing shall be "available solely for families whose income at the time of admission does not exceed five times the rental (including the value or cost to them of heat, light, water and cooking fuel) of the dwellings to be furnished such families, except that in the case of families with three or more minor dependents such ratio shall not exceed six to one."

It occurred to me that the readers of TECH ENGINEERING NEWS might find it of particular interest to have a picture of the operation of a large housing project that was made possible by Government help. I select Hillside Homes largely

(*Continued on page 51*)

As Modern as Tomorrow

Simplex-ANHYDREX deproteinized rubber insulation is a perfect example of the value of research to industry. The Simplex research engineers strove for many years to find a rubber insulation that would not absorb harmful quantities of water.

They finally found it and now all industry can share the results of this research by specifying and buying wires and cables insulated with Simplex-ANHYDREX, the low water absorption insulation made with deproteinized rubber.

It does not need the protection of a lead sheath thus making the completed cable lighter and easier to handle and install.

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Illustrated above is the New 1938 Model 9" x 31' South Bend WORKSHOP Motor Driven Precision Back Geared Screw Cutting Engine Lathe, price $117., F. O. B. South Bend, Indiana.

More than 39 practical attachments available for this lathe.

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LOW-INCOME HOUSING

(*Continued from page 50*)

because I happen to know most about it, and also because it is a good example of the beneficent and wise use of Government funds for housing.

This modern housing development is located in the Borough of the Bronx, New York City, and comprises an area of 617,553 square feet. The buildings occupy an area of 239,093 square feet, so the coverage is about 39 per cent. This figure indicates an important growth in housing policy. Think of the apartment houses and homes in the best sections of our cities and you will find none that provide such a large percentage of area for open garden spaces. Public housing has made an important contribution to American standard of living in this regard.

This development consists of 110 walk-up fireproof four-story buildings and 4 elevator six-story fireproof buildings. These buildings are divided into five units, each unit being separated from the others by spacious lawns amply landscaped. There are 1416 apartments and 4948 rooms. In addition to the apartments there are administrative offices, waiting rooms, an auditorium, nursery rooms, a community director's office, community kitchens, children's playgrounds, shelters, playgrounds having very modern facilities, two wading pools, maintenance shops and storerooms, carriage rooms, trunk rooms, club rooms, meter rooms, boiler rooms and work shops of various kinds.

The tenants are selected most carefully, the objective being to give preference to those in the low-income groups who are worthy and dependable.

The income of 25% of the families is less than $2,000 a year, and 55% have incomes of less than $3,000 a year. They pay an average of $11.00 per room per month, the renting including heat and hot water. The tenants pay for light, gas and current for refrigerators.

RESEARCH IN REVIEW

(*Continued from page 45*)

Mr. E. A. Johnson is investigating the determination of stresses in rigid frame structures by means of brass wire models.

Mr. O. T. Voodhigula is investigating the determination of influence lines for continuous beams by means of splines.

In addition to various testing machines, the laboratory is equipped with a small machine shop. The simultaneous calculator, developed at M.I.T. for solving linear simultaneous equations, is kept in the structural analysis laboratory and is used in connection with the research.

This work is being carried on under the general supervision of Professor C. B. Breed, Head of the Department of Civil and Sanitary Engineering. Professor J. B. Wilbur is in direct charge.

CAMBRIDGE TORSIONAL DAMPING RECORDER

This machine determines and records (on celluloid film) the internal damping capacity of any structural material such as steel, aluminum, ebonite, bakelite, or wood—a property of considerable importance in resonance investigations. Frequently the suitability of a material is more properly determined by this property than any other.

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ORGANIC CHEMISTRY

(*Continued from page 39*)

these agents, such as higher alcohols and xanthates of the alkali metals, are added to the slurry of finely-ground ore, a froth is formed which entraps the particles rich in metal. The froth is skimmed off and then you have a valuable concentrate. This technique is applicable to other minerals such as silver, lead, zinc, and even phosphate rock.

Other striking examples of organic chemistry in overalls are the use of complex organic bases such as the guanidines as accelerators of rubber vulcanization; the use of lead tetraethyl as a dampener or "anti-knock" in internal combustion engines; and the use of higher alcohol sulphates as detergents and wetting-out agents in the textile industry. In each of these instances, one is impressed not only by the technical effects that are secured, but by the concomitant economic effects. Thus, a few cents expended for organic chemicals creates several dollars equivalent of wealth in terms of increased utility of the product to which it is applied.

The increasingly close alliance between experimental medicine and the synthetic organic chemist has led to new startling discoveries in the field of the hormones, those interesting and often complex organic catalysts so vitally important to both plant and animal life. These developments, which I hope are but preliminary results, serve to illustrate a point of the argument that enlisting the services of the chemist in building molecules to pharmaceutical specifications will certainly prove of importance in the next few years. But the illustration of the use of frothing agents and collectors in the mining industry naturally leads one to speculate as to the benefits still awaiting an increasingly close alliance between the experimental physicist and medical research. Very little attention has been given to the question of the physical reactions involved in the vital processes. The devising of compounds designed to function more in a physical way than in a purely chemical way is a little-cultivated field. One striking exception to this statement as to the benefit to be derived from physics is the use of physical means for aiding the processes which occur in the alimentary tract. I have no doubt that compounds designed to bring about physical reactions in the human body, and the physical elucidation of the nature of some very complex reactions of the human metabolism await much further research.

There will be, I expect, greatly increased specialization in medical research laboratories just as there has been considerable specialization in the development of such laboratories as the following which are maintained by the du Pont Company and which serve to illustrate the point:—

Pest Control Laboratory, for development of insecticides and fungicides.

Rubber Chemicals Laboratory, for development of vulcanization accelerators, rubber anti-oxidants, softeners.

Dyestuffs Laboratory, for development of dyestuffs, textile assistants, textile finishing materials.

These laboratories are quite apart from other laboratories engaged in general exploration and development work. From them and from similar laboratories in other companies and institutions, we may expect the answers to many of the unsolved questions always before a broadening and expanding industry.

After the same fashion, also, we may hope for the development of many, much more specialized, laboratories designed for the investigation of specific segments of the physical and chemical reactions involved in the complex and diversified functions of the human machine, and with comparably accelerated progress in the understanding of these functions and the development of aids and remedies for the various types of reactions comprised in the human metabolism.

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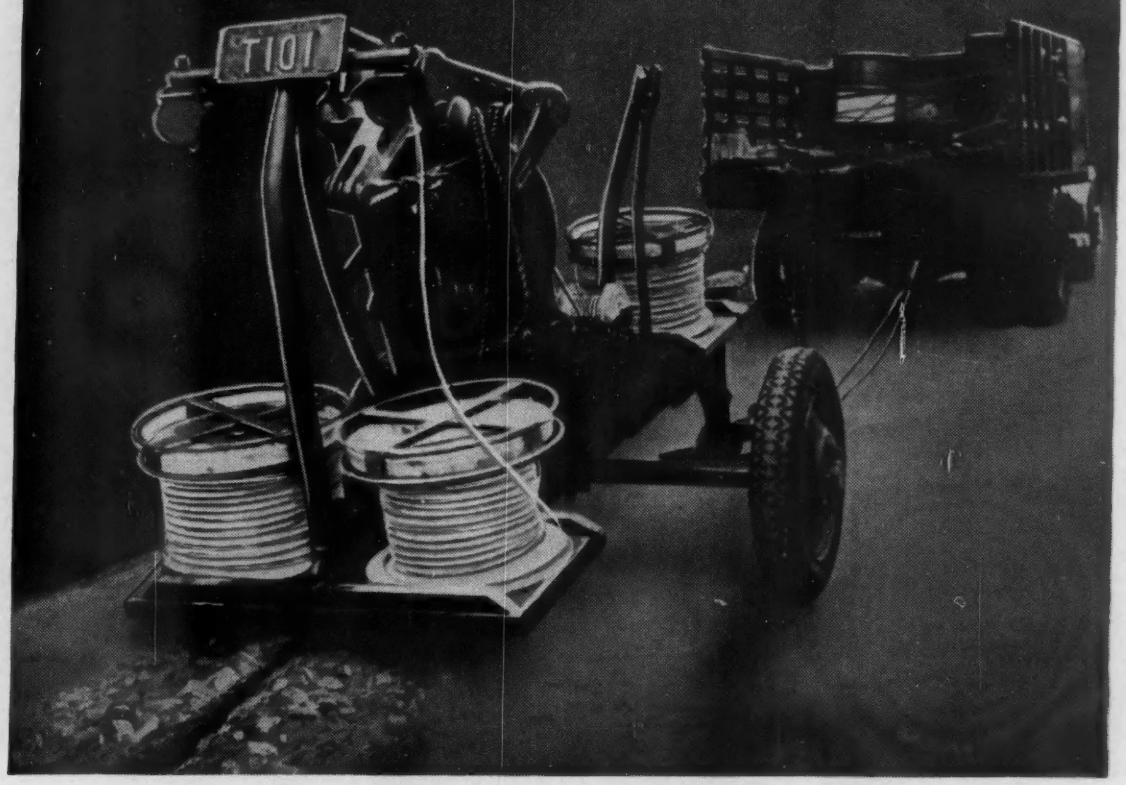

RURAL telephone wire—*not in cables*—can now go underground where bad weather and grass fires can't harm it.

To make this possible, an entirely new kind of wire had to be developed. Special insulating compounds, special splicing methods were devised. Then a simple, economical method of burial had to be found. A special plow solved this problem—one that digs a furrow and tucks away the wire in a single operation.

Just one more step in the process of making Bell System service constantly more dependable.

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Why not telephone home tonight? Rates to most points are lowest any time after 7 P. M. and all day Sunday.

G-E *Campus News*

"SOUPED" ENGINES FOR SIX-MILE HEIGHTS

AS THE bellows is to the forge, so is the supercharger to the airplane engine. Because of the rarefied atmosphere at high elevations, airplane engines require superchargers which operate like fan blowers, maintaining air pressure in the engines and permitting the motor to operate at normal efficiency.

Today, twelve-hour flights from coast to coast at an average height of six miles are the objective of transport airlines. Experiments in this field have been successfully conducted by Transcontinental and Western Air, Inc., and the U.S. Army Air Corps with very encouraging results, using G-E turbine-driven superchargers.

Military, transport, racing, and transoceanic planes are equipped with G-E superchargers which increase motor efficiency, speed, and flying distance. The superchargers were developed by Dr. S. A. Moss, of General Electric and are built in the River Works in Lynn, Mass. Student engineers on Test at Lynn have an opportunity to inspect and test these devices as a part of their training course.

BEATING SWORDS INTO PLOWSHARES

WELL, not exactly swords into plowshares, but rather discarded rails, superheaters, and boiler tubes into steel for the overhead system of an electrified railroad line. In this manner the old steam railroad of the Witwatersrand Gold Mining Area was replaced by a completely electrified line.

Because of the rise in gold prices during the last few years, an increased suburban passenger traffic in that section of South Africa necessitated an enlargement of the railroad.

Mercury-arc rectifiers made by the British Thomson-Houston Company, an affiliate of General Electric, supply the power for the "Reef Scheme," as it is called, while 115 four-motor, multiple-unit car equipments were furnished by G.E. through the International General Electric Company.

The engineering and sales work on this project was done by several former G-E Test men. Many such opportunities are open to graduates of college engineering schools who have successfully completed the G-E Test Course.

AMERICA'S OUTSTANDING YOUNG ELECTRICAL ENGINEER

DR. CHAUNCEY GUY SUITS, research physicist of the General Electric Research Laboratory, in Schenectady, has been named by Eta Kappa Nu, honorary electrical engineering fraternity, as the outstanding young electrical engineer for 1937.

Born in Oshkosh, Wisconsin in 1905, Dr. Suits graduated from the University of Wisconsin in 1927 and from the Technische Hochschule in Zurich, Switzerland (Sc.D. '29). An ardent skier, he spends most of his spare time on the snowy slopes around upper New York State.

As a member of the Research Laboratory staff, his work has been on the fundamentals of electric arcs, showing how arc temperature can be measured by sound, and it was for this work that the Eta Kappa Nu award was given him. Other activities for which Dr. Suits is noted include the investigation of non-linear circuits, high-pressure arcs, and the development of automatic tuning for radio receivers.

Last year the award was given to Frank M. Starr, U. of Colorado '28, G-E Test '29, who is employed in the Central Station Engineering Department of General Electric. The Test Course, of which Starr is an alumnus, provides a practical education supplementary to the theoretical knowledge obtained in college.

GENERAL ELECTRIC

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